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THE MARLBOROUGH FORAY.

THE 1927 Spring Foray was held at Marlborough during the Whitsun week-end, June 3rd to June 7th. Through the kind offices of Mr A. G. Lowndes, the Society was allowed the use of the Biological Laboratory of Marlborough College, and the facilities for microscopic work and reference to literature thus provided were very much appreciated.

About twenty members and visitors assembled on Friday evening, June 3rd. On Saturday, June 4th, the morning was spent in Savernake Forest. Unfortunately the previous dry weather, combined with the absence of undergrowth beneath the beeches, made this excursion a disappointing one from the mycological point of view, very little of interest being recorded. After lunch at the Monument in the Forest, a move was made by motor to Bedwyn Brail. There the vegetation along the canal bank yielded various parasitic fungi, such as *Ustilago longissima*, *Puccinia variabilis* on *Taraxacum*, *Protomyces pachydermus* also on *Taraxacum*, and a fungus on leaves of *Apium nodiflorum* which has not yet been satisfactorily identified.

A visit to the kitchen garden of the College on Sunday morning added to the list some of the species which are parasitic on cultivated plants. In the afternoon West Wood was explored, where conditions were found to be more favourable to the growth of such fungi as are to be expected in spring. Rich undergrowth with fallen logs produced a fairly satisfactory list of species. One of the features of this wood was the abundance and very fine condition of the aecidium of *Melampsora Rostrupii* (*Caeoma Mercurialis*) on Dog's Mercury. Other microfungi found were *Uromyces Alchemillae*, *Endophyllum Euphorbiae-silvaticae* on the Wood Spurge, and *Puccinia Saniculae* on Sanicle. *Plasmopara pusilla* was found on *Geranium pratense* growing by the road side. Both here and in Savernake Forest, *Micropodia pteridina* was found to be abundant at the base of bracken stems in rather damp spots. The species is undoubtedly very common, but owing to its habitat is easily overlooked. Resupinate Hymenomycetes were scarce and nothing of any special interest was noted.

On the Monday, the party motored first to Martinsell Hill, where a small plantation and the grassy slopes were worked over. *Xylaria carpophila* was detected on beech mast, and from some spotted Rhododendron leaves *Phoma Rhodorae* was subsequently identified. After lunch Manningford Bruce and its neighbourhood were explored, and here again better luck was obtained in damp spots near and along the canal.

As will be seen from the list, the larger fungi were scarce throughout the Foray. This condition had however its advantages, for members were able to give more time to the microscopic forms, and with the unusual facilities for microscopic work it was possible to get many species named at once, thus considerably lightening the subsequent work required for making up the list.

During the course of the meeting various exhibits were shown. Mr F. A. Mason sent specimens of *Cyathipodia Corium*. Mr A. D. Cotton showed specimens of *Melampsora Larici-populina* on *Populus generosa* collected at Hereford in 1926, and gave an account of some inoculation experiments which had been carried out by Professor Klebahn to establish the identity of the fungus. Examples were shown of the *Caeoma* on Larch produced by inoculation with the uredospores from *Populus generosa*, and of the uredospore stage produced again on *Populus nigra* and *P. generosa* by inoculation with aecidiospores from the Larch. Miss Wakefield showed fresh specimens of *Puccinia mirabilissima* on *Mahonia* from Scotland, and pointed out that some of the leaves showed an aecidium associated with the teleutospore sori. In 1888 Tracy and Galloway had reported finding an aecidium with this species, but not in close association with the teleutospores, so that its connection had been doubted. The Scottish material suggested that the two spore-forms really belonged to the same species. *Rhabdocline Pseudotsugae*, recently recorded from the south of England, was also shown, and a brief account given of what little is known as to its introduction and spread in this country. Dr Butler, who was unfortunately unable to be present, sent preparations of a fungus from glacial clays underlying peat bogs in Western Canada, which had been submitted to him by Professor Lewis, of Alberta. The fungus resembled closely the vesicle-bearing fungus commonly found in endotrophic mycorrhizas and soils at the present day.

A short business meeting was held in order to elect new members and to discuss suggestions for the Spring Foray in 1928. Oxford was agreed upon as a suitable locality, but if this should be found not practicable Wisley was to be adopted as an alternative.

Apart from mycological work the Marlborough meeting was most enjoyable and interesting from its association with Marlborough College. On the Sunday, through the kindness of the Master, members of the party were allowed to attend Morning Prayer in the College Chapel, and afterwards were shown over the College. Incidentally the College added one fungus to the Foray list, named *Merulius lacrymans*, which was pointed out as being a terrible pest in damp cupboards in the Armoury.

At the close of the meeting, on the Monday evening, very hearty votes of thanks were passed to the Master of Marlborough College and to Mr Lowndes for the hospitality shown and the excellent arrangements made for the Foray, and to the boys of the College who had assisted as guides during the excursions.

For assistance in compiling the subjoined list the Secretary is indebted to all the members present.

Complete List of Species collected during the Foray.

S. = Savernake Forest; *B.* = Bedwyn Brail; *C.* = Marlborough College kitchen garden; *W.* = West Wood; *M.* = Martinsell Hill; *N.* = Manningford Bruce and neighbourhood.

HYMENOMYCETES.

Amanita rubescens (Pers.) Fr., *S.*
Armillaria mellea (Vahl) Fr. (rhizomorphs), *S.*, *W.*
Marasmius dryophilus (Bull.) Karst., *M.*
Panus stipticus (Bull.) Fr., *W.*, torulosus (Pers.) Fr., *B.*
Entoloma rhodopolium Fr., *M.*
Hypholoma fasciculare (Huds.) Fr., *M.*
Boletus granulatus (Linn.) Fr., *M.*
Polyporus squamosus (Huds.) Fr., *S.*, *B.*, *N.*, betulinus (Bull.) Fr., *S.*, *W.*, adustus (Willd.) Fr., *S.*
Fomes annosus Fr., *W.*, ferruginosus (Schrad.) Mass., *S.*, *W.*
Ganoderma applanatum (Pers.) Pat., *S.*
Polystictus versicolor (Linn.) Fr., *S.*, *C.*
Poria gilvescens Bres., *S.*
Trametes gibbosa (Pers.) Fr., *N.*, mollis (Sommerf.) Fr., *W.*
Irpex obliquus (Schrad.) Fr., *S.*, *W.*
Merulius lacrymans (Wulf.) Fr., *Armoury of Marlborough College.*
Grandinia granulosa Fr., *M.*, farinacea (Pers.) Bourd. & Galz., *W.*
Hypochnus fuscus (Pers.) Fr., *W.*, isabellinus Fr., *B.*, fumosus Fr. (mycelium only), *S.*
Stereum rugosum (Pers.) Fr., *S.*, hirsutum (Willd.) Fr., *W.*, purpureum (Pers.) Fr., *S.*
Hymenochaete rubiginosa (Dicks.) Lév., *S.*, corrugata (Fr.) Lév., S.
Corticium arachnoideum Berk., *W.*, botryosum Bres., *S.*, comedens (Nees) Fr., *W.*, porosum Berk. & Curt., *B.*, *W.*, *M.*, praetermissum (Karst.) Bres., *W.*
Peniophora leprosa Bourd. & Galz., *N.*, cremea Bres., *N.*, velutina (DC.) Cooke, *W.*, setigera (Fr.) Bres., *W.*, hydnoides Cooke & Mass., *S.*, *W.*, incarnata (Pers.) Cooke, *M.*, cinerea (Fr.) Cooke, *M.*, quercina (Pers.) Cooke, *W.*, *M.*, *N.*
Auricularia mesenterica (Dicks.) Fr., *W.*, auricula-Judae (Linn.) Schroet., *M.*
Tremella frondosa Fr., *W.*
Exidia glandulosa (Bull.) Fr., *W.*
Dacryomyces deliquescens (Bull.) Duby, *N.*
Calocera cornea (Batsch) Fr., *W.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *S.*

UREDINALES.

Uromyces Acetosae Schroet., *B.*, Alchemillae (Pers.) Lév., *W.*, Valerianae (Schum.) Fuck., *W.*, Scillarum (Grev.) Wint., *W.*
Puccinia Violae (Schum.) DC., *W.*, malvacearum Mont., *B.*, *C.*, pulverulenta Grev., *B.*, *N.*, Saniculae Grev., *W.*, Adoxae Hedw. fil., *M.*, obtegens (Link) Tul., *B.*, *W.*, Leontodontis Jacky, *M.*, variabilis Grev., *B.*, *N.*, *W.*, Taraxaci Plowr., *C.*, Primulae (DC.) Duby (aecidium), *W.*, Menthae Pers.

(aecidium), *C.*, Acetosae (Schum.) Koern., *W.*, Buxi DC., *N.*, Caricis (Schum.) Rebent., *B.*, *N.*, graminis Pers. (aecidium), *S.*, *N.*, Lolii Niels. (aecidium), *S.*, Phalaridis Plowr. (aecidium), *M.*, *C.*, Phragmitis (Schum.) Koern., *W.*, *N.*, Poarum Niels., *B.*, *N.*, *C.*
Triphragmium Ulmariae (Schum.) Link, *N.*
Phragmidium violaceum (Schultz) Wint., *B.*, *C.*, *M.*
Coleosporium Senecionis Fr. (aecidium), *M.*
Endophyllum Euphorbiae-silvaticae (DC.) Wint., *W.*
Melampsora Rostrupii Wagn. (aecidium), *S.*, *W.*, *M.*
Melampsorella Symphyti (DC.) Bubák, *N.*

USTILAGINALES.

Ustilago violacea (Pers.) Fuck., *N.*, longissima (Sow.) Tul., *B.*, *N.*, perennans Rostr., *N.*

HYSTERIALES.

Dichaena quercina (Pers.) Fr., *W.*, faginea Fr., *S.*, *M.*

DISCOMYCETES.

Ciliaria scutellata (Linn.) Quél., *S.*
Orbilia xanthostigma Fr., *S.*, leucostigma Fr., *S.*
Chlorosplenium aeruginosum (Oeder) de Not., *S.*
Helotium herbarum (Pers.) Fr., *W.*
Dasyscypha virginea (Batsch) Fuck., *S.*, *W.*, fuscescens (Pers.) Rehm, *B.*, *W.*, *M.*
Arachnopeziza aurelia (Pers.) Fuck., *S.*
Trichoscypha calycina (Schum.) Boud., *M.*
Hyaloscypha hyalina (Pers.) Boud., *N.*
Micropodia pteridina (Karst.) Boud., *S.*, *W.*
Mollisia cinerea (Batsch) Karst., *S.*, *W.*, *M.*
Pseudopeziza Trifolii (Biv.-Bern) Fuck., *W.*, *N.*
Colpoma quercinum (Pers.) Wallr., *S.*
Rhytisma acerinum (Pers.) Fr., *M.*

PYRENOMYCETES.

Podosphaera leucotricha (Ell. & Ev.) Salm., *C.*
Erysiphe Galeopsidis DC. on *Lamium purpureum*, *B.*, graminis DC., *W.*, *N.*
Phyllactinia corylea (Pers.) Karst., on *Cornus*, *W.*
Nectria episphaeria (Tode) Fr., *S.*, *W.*, galligena Bres., *C.*
Epichloe typhina (Pers.) Tul., *M.*
Rosellinia aquila (Fr.) de Not., *W.*
Ceratostomella rostrata (Fr.) Sacc., *B.*
Stigmatea Robertiani Fr., *C.*, *N.*
Mycosphaerella brassicicola (Duby) Lindau, *B.*, Fragariae (Tul.) Lindau (conidia only), *B.*, *C.*
Venturia inaequalis Aderh. (conidia only), *C.*
Leptosphaeria acuta (Moug. & Nestl.) Karst., *B.*
Diaporthe Spina Fuck., *N.*
Diatrype Stigma (Hoffm.) de Not., *S.*, *W.*, *N.*, disciformis (Hoffm.) Fr., *S.*, *W.*
Hypoxylon multiforme Fr., *S.*, *W.*, fuscum (Pers.) Fr., *W.*
Daldinia concentrica (Bolt.) Ces. & de Not., *S.*
Xylaria Hypoxylon (Linn.) Grev., *S.*, *M.*, *N.*, carpophila (Pers.) Fr., *M.*
Ustulina vulgaris Tul., *S.*
Endodothella Junci (Fr.) Theiss. & Syd., *S.*
Rhopographus Pteridis (Sow.) Wint., *S.*, *W.*, *N.*

PHYCOMYCETES.

Synchytrium Taraxaci de Bary & Wor., *M.*, *N.*
Cystopus candidus (Pers.) de Bary, *S.*, *C.*, cubicus (Strauss) de Bary, *N.*
Plasmopara pusilla (de Bary) Schroet., *W.*
Bremia Lactucae Regel, *C.*
Peronospora trifoliorum de Bary, *W.*, *N.*, parasitica (Pers.) Tul., *B.*, *C.*

PROTOMYCETACEAE.

Protomyces macrosporus Unger, *C.*, pachydermus Thuem., *B.*, *C.*

DEUTEROMYCETES.

Phyllosticta hedericola Dur. & Mont., *B.*, *W.*
Phoma conigena Karst., *B.*, Rhodorae Cooke, *M.*
Ascochyta Pisi Lib., *C.*
Septoria Petroselini Desm., *C.*, Rubi West., *M.*
Coniothyrium Fuckelii Sacc., *C.*
Diplodia salicina Lév., *N.*
Gloeosporium concentricum Grev., *B.*
Discella carbonacea (Fr.) B. & Br., *N.*
Oidium alphitoides Griff. & Maubl., *W.*
Ovularia obliqua (Cooke) Oud., *B.*, *C.*, *M.*, *N.*
Botrytis cinerea Pers., *C.*, *M.*
Rhinotrichum repens Preuss, *S.*
Didymaria didyma (Unger) Schroet., *N.*
Ramularia lactea (Desm.) Sacc., *B.*, beticola Fautr. & Lamb., *C.*, Valerianae (Speg.) Sacc., *W.*, Primulae Thuem., *W.*, Taraxaci Karst., *N.*, Urticae Ces. *N.*, Calthae Lindr., *N.*
Trichoderma viride (Pers.) Fr., *B.*
Cladosporium herbarum (Pers.) Link, *C.*, *N.*
Cercospora Mercurialis Pass., *M.*
Isaria farinosa Fr., *S.*, *W.*

LICHENS OF THE MARLBOROUGH FORAY.

THIS list contains only arboreal Lichens growing on trees and palings. Saxicolous Lichens were scarce owing to the absence of exposed rocks in the districts visited, and only a few of the common species were seen on walls. Savernake Forest consisted mostly of beech trees with a few oaks. The old trees near the Grand Avenue were the most prolific in Lichens. Here *Thelotrema lepadinum* and *Lecanactis abietina* were plentiful. On an old oak tree there was a large patch of *Lobaria laetevirens*. This with other species of the family Stictaceae is becoming very rare in many of the southern and midland counties owing to the cutting down of old woods. On this same oak was found *Rinodina roboris* and the sterile thallus of *Pertusaria lutescens*. Also *Chaenotheca chrysocephala* was apparently common near the Grand Avenue, but apothecia were scarce.

Few Lichens were noticed on the Monday excursion except on some Elders on the slopes of Martinsell Hill near Oare. Here were found *Cetraria chlorophylla, Parmelia acetabulum, Lecania syringea* and *Bilimbia Nitschkeana.*

In the following list *S.* = Savernake Forest; *B.* = Great Bedwyn; *M.* = Martinsell Hill.

Chaenotheca chrysocephala Th. Fr., *S.*
Lobaria laetevirens Zahlbr., *S.*
Parmelia physodes Ach.
P. perlata Ach., *M.*
P. caperata Ach.
P. saxatilis Ach.
P. sulcata Tayl.
P. dubia Tayl.
P. acetabulum Dub., *M.*
P. fuliginosa Nyl. var. laetevirens Nyl.

Cetraria chlorophylla Wain., *M.*
Evernia prunastri Ach.
Ramalina fraxinea Ach., *B.*
R. fastigiata Ach.
R. farinacea Ach.
Usnea florida Web. var. hirta Ach.
Xanthoria parietina Th. Fr.
X. polycarpa Oliv.
Physcia stellaris Nyl.
P. hispida Tuckerm.
P. orbicularis var. virella Dalla Torre & Sarnth.
Rinodina roboris Arn., *S.*
Lecanora subfusca Ach.
L. rugosa Nyl.
L. Hageni Ach.
L. carpinea Wain.
L. varia Ach.
L. symmicta Ach.
L. symmictera Nyl.
Lecania syringea Th. Fr., *M.*
Pertusaria globulifera Nyl.
P. faginea Leight.
P. multipuncta Nyl., *S.*
P. pertusa Dalla Torre & Sarnth.
P. leioplaca Schaer.
P. lutescens Lamy, *S.*
P. Wulfenii DC.
Thelotrema lepadinum Ach., *S.*
Phlyctis argena Koerb.
Lecidea parasema Ach.
Biatorina cyrtella Th. Fr.
B. Griffithii Massal.
Bilimbia Naegelii Anzi, *S.*
B. Nitschkeana Lahm., *M.*
Bacidia luteola Mudd, *B.*
Buellia canescens de Not.
B. myriocarpa Mudd
Lecanactis abietina Koerb., *S.*
Arthonia radiata Ach.
and var. Swartziana Sydow
Opegrapha atra Pers.
O. betulina Sm.
O. varia Pers.
O. vulgata Ach.
Graphis elegans Ach.
G. scripta Ach.
Phaeographis inusta Muell.-Arg., *S.*
Enterographa crassa Fée
Acrocordia gemmata Koerb.
Arthopyrenia fallax Arn.
Pyrenula nitida Ach.

LIST OF MYCETOZOA FOUND AT MARLBOROUGH.

By H. J. Howard.

S. = Savernake Forest; *M.B.* = Manningford Bruce; *M.* = Martinsell.

Badhamia utricularis Berk. (plasmodium), *M.*
Physarum nutans Pers., *S.*
Fuligo septica Gmel., *S.*
Diderma hemisphericum Hornem., leaf heap, College Garden.
Didymium squamulosum Fr., *S.*
Stemonitis fusca Roth., *S.*, *M.* (also developed from plasmodium).
Comatricha nigra Schroet., *S.*
C. typhoides Rost., *S.*
Reticularia Lycoperdon Bull., *S.*, *M.*
Lycogala epidendrum Fr., *M.B.*, *M.*, *S.*
Trichia affinis de Bary, *S.*
T. persimilis Karst., *S.*
T. varia Pers., *M.*, *S.*, *M.B.*
T. Botrytis Pers., *S.*
Arcyria denudata Wetts., *S.*
A. incarnata Pers., *S.*
Ligniera Junci (Schwartz) Maire & Tison, *M.*

NOTES ON NEW OR RARE FOREST FUNGI.

By Malcolm Wilson, D.Sc., University of Edinburgh and John S. L. Waldie, B.Sc., Forestry Commission.

(With Plate VIII.)

THE fungi which are discussed in the following paper all occur on conifers and the majority are saprophytes although some under certain conditions may become parasitic. With the exception of *Menoidea Abietis* the fructifications whether perithecial, pycnidial or conidial, all possess a stalk-like base which occupies the stomatal cavity and gives a characteristic appearance to the fungi. The arrangement of the fructifications is thus dependent on the stomatal distribution. The fungi are usually found associated, and the majority of them were described by French mycologists early in this century. Their occurrence in Britain appears to be similar to that on the continent.

RHIZOSPHAERA PINI (Corda) Maub.

On the leaves of *Abies grandis*. Bagley Wood, Oxford. February 1927.

This species, not previously recorded in Britain, was described in 1907 from Jura, France, as *Rhizosphaera Abietis* by Mangin and Hariot (*Bull. Soc. Myc. France*, XXIII, 54), who instituted the genus. Later in the same year Maublanc (*tom. cit.* p. 169) pointed out that *R. Abietis* was identical with *Coniothyrium Pini* Corda; he accordingly re-named it *Rhizosphaera Pini* (Corda) Maub.

It is placed by Mangin and Hariot in the Sphaeropsidaceae. Pycnidia are formed by the outgrowth, through the stomatal opening, of a dense mass of pale brown, thick-walled hyphae. The hyphae are preceded by a small mass of white waxy substance, normally present on the leaf, which partially blocks up the stomatal aperture. It can easily be seen on the surface of the pycnidium, serving as a useful distinguishing character for the genus *Rhizosphaera*. The few hyphae which grow up through the stomatal aperture, spread out in a fan-shaped manner, and are continuous with the wall of the pycnidium, which consists of a single layer of dark-coloured cells. The rows of pycnidia corresponding to the stomatal arrangement on the under surface of the needles of the silver fir are characteristic of the fungus. The mature pycnidium is ovoid to spherical in form and measures from 90 to 120μ in diameter. The spores are unicellular, hyaline, ovoid and 16 to 20 $\times$ 8μ in size.

Mangin and Hariot described and illustrated two forms of

spore development; (1) in which they are budded off from the pycnidial wall and (2) where they are borne on long sporophores arising from the base of the pycnidium. So far only the first mentioned form of spore development has been seen in the British material. Otherwise the fungus agrees with their description.

Rhizosphaera Kalkhoffii Bubák.

This species which was observed in 1922 on the leaves of *Picea pungens* var. *argentea*, has already been recorded by the writers (*Trans. Roy. Scot. Arbor. Soc.* XL, 34–6), as well as the other hosts on which it has been found. It was first described in Germany by Bubák (*Ber. deut. bot. Gesell.* XXXII (1916), 188). It generally resembles *R. Pini*, but differs in the smaller size of its spores and the absence of any obvious sporophores. Von Höhnel (*Sitz.-Ber. K. Ak. d. Wiss. Wien*, CXV (1916), 63) states that *R. Kalkhoffii* should be placed in the genus *Sclerophoma* as the spores are derived directly from the wall of the pycnidium. Van Luyk (*Ann. Mycol.* XXI (1923), 136), however, considers that it more closely resembles the genus *Rhizosphaera*. As pointed out and illustrated in the paper already referred to, *R. Kalkhoffii* possesses a well marked stalk-like basal portion made up of thick-walled twisted hyphae, which passes through the stomatal opening (Pl. VIII, fig. 1) and in this agrees with *R. Pini*. It also closely resembles this fungus in the structure of the wall of the pycnidium. Although the fungus might be placed in the genus *Sclerophoma*, it appears preferable to assign it to the more strictly defined genus *Rhizosphaera*.

Adelopus balsamicola (Peck) Theiss.

On dead leaves of *Abies pectinata*, Murthly, Perthshire, April, 1926, and on leaves of *Pseudotsuga Douglasii*, Devon, May, 1927, and Antrim, Ireland, June, 1928.

The species was found in association with *Rhizosphaera Kalkhoffii* and does not appear to have been previously recorded for Britain. The first description was given in 1881 by Peck (*34th Report of the State Botanist of the Museum*, New York, p. 52) as *Meliola balsamicola* on the leaves of *Abies balsamea* in the United States. In his account he says, "our fungus does not fully meet the requirements of the genus *Meliola*, neither is it a good *Asterina* nor *Dimerosporium*." Again in 1885, Peck (*38th Report*, p. 102) recording the same fungus under the name of *Asterina nuda* stated its similarity externally with *Sacidium Pini* (which is synonymous with *Rhizosphaera Pini*). The fungus was later referred to *Dimerosporium* by Ellis and Everhart (*North American Pyrenomycetes*, p. 728, 1892) as *D. balsamicolum* (Peck) Ell. & Everh.

In 1914 Theissen (*Ann. Mycol.* XII, 72) described the fungus as *Cryptopus nudus* (Peck) Theiss., placing it in a new genus which he instituted for it. At the same time he described and figured a conidial stage which remarkably resembles (though he does not say so) *Toxosporium camptospermum*. Later (*Ann. Mycol.* XV (1917), 482), he changed the generic name to *Adelopus*, because there is a genus *Cryptopus* in the Orchidaceae. He also identified Peck's earlier species (*Meliola balsamicola*) as the same, and proposed the combination *Adelopus balsamicola* (Peck) Theiss.

Theissen placed the genus *Adelopus* in the Capnodiaceae but in our opinion it comes much nearer to the Sphaeriaceous fungi.

The perithecium grows out through the stoma, in a like manner to *Rhizosphaera*, pushing in front the white waxy plug which can be seen on the summit of the fructification. Both Peck and Theissen state that the fungus has a superficial mycelium, though in the latter's drawing (*Ann. Mycol.* XII, Pl. VI, figs. 1–3) he shows also an abundant mycelium within the leaf tissues of the host. The British specimens show a very scanty external mycelium, confined to the base of the perithecium. The mature perithecium is globose to ellipsoidal in form, narrowing rather suddenly into the stalk-like basal portion, while the outer wall is black and shining. The perithecium measures from 70 to 80μ in height and 90 to 120μ in diameter. Each contains several club-shaped or cylindrical asci, varying in size from 36 to 50 × 12 to 15μ. There are no paraphyses. The ascospores are hyaline, uniseptate, distichous and 10 to 12 × 3 to 4μ in size.

As *Adelopus balsamicola* was found along with *Rhizosphaera Kalkhoffii* Bub. on the dead needles of silver fir, it is interesting to note that Maublanc (*Bull. Soc. Myc. France*, XXIII (1907) 171) found in Jura, France, young immature perithecia which he looked upon as representing the ascigerous stage of *Rhizosphaera Pini*. The ascospores were not ripe and there were no paraphyses. Vuillemin found similar immature perithecia in 1896. We are not in a position to state the connection between the two species as no cultural work has been carried out.

Phaeocryptopus Abietis Naoumoff.

The presence of a fungus on the leaves of *Pinus Armandi* Forrest and *Abies Faxoniana* Rehd. & Wils., collected in N.W. Yunnan, China, by Mr George Forrest in 1912 and 1921 respectively, was brought to our notice by Mr M. Y. Orr of the Royal Botanic Gardens, Edinburgh. This species was first described by Naoumoff (*Bull. Soc. Myc. France*, XXX (1914), 424) from Perm, Russia, on the leaves of *Abies sibirica*

Ledeb. The genus *Phaeocryptopus* was constituted for its reception, as it differs from *Cryptopus*, now known as *Adelopus* only in the presence of paraphyses and the brown colour of the ascospores.

The Yunnan specimens agree with the description given by Naoumoff. The perithecia (Pl. VIII, fig. 2) are developed like those of *Adelopus* and vary from 85 to 120μ in diameter by 90 to 130μ in height, with rather cylindrical asci, 48 to 64 × 12 to 16μ in size. The paraphyses are filiform, hyaline, and 70 × 2·5μ. The ascospores are distichous, uniseptate, becoming a smoky brown colour towards maturity and 16 to 20 × 5·5 to 8μ.

Toxosporium camptospermum (Peck) Maub.

This fungus was found on leaves of *Abies pectinata* in Argyllshire in 1925. First described by Peck (*39th Report* (1886), p. 48) as *Pestalozzia camptosperma* in the United States on leaves of *Abies balsamea* and later placed by Saccardo (*Syll. Fung.*, XVIII, 485, 1906) in the genus *Monochaetia*. Vuillemin (*Bull. Soc. Myc. France*, XII, 33) found the fungus in France in 1896 on *Abies pectinata*, described it as a new species and placed it in the new genus *Toxosporium* as *T. abietinum*. In 1907 Maublanc (*Bull. Soc. Myc. France*, XXIII, 173) recognising its identity with *Pestalozzia camptosperma* changed the name to *Toxosporium camptospermum* (Peck) Maub.

Rostrup (*Bot. Tidsskr.* XXII, 271) described the same fungus on *Abies pectinata* from Denmark in 1898 as *Coryneum bicorne*. Lind (*Danish Fungi*, p. 204, 1913) states that Rostrup supposed it to be a conidial stage of *Mycosphaerella Abietis* (Rostrup) Ldau. (*Rehmiellopsis bohemica* Bub. & Kabat), while Theissen (*Ann. Myc.* XIII (1914), 72) gave as a conidial stage of *Crytopus nudus* a form which, from his description and figure, closely resembles *Toxosporium camptospermum*. Oudemans (*Ned. Kr. Arch.* 2 (1904), 1119) described and figured the same fungus from Holland in 1903.

The genus is described by Vuillemin as follows:

"*Toxosporium*. Acervuli sublenticular, erumpent, scattered, minute, black; conidia curved, beaked at each end, 3 to 5-septate, the two inner cells opaque, the apical hyaline; conidiophores short, simple."

It is placed by Maublanc in the Melanconiaceae. The species is described as follows:

"*T. abietinum* [*camptospermum*]. Acervuli, pulvinate, stromatic, 100 to 250μ wide, turning black, erumpent, surrounded by the ruptured epidermis; conidia curved, centre swollen, 18 to 24μ long, 7·5 to 8μ wide in the convex middle part, conidiophores 5 to 6 × 1·5 to 2μ."

The Scottish specimens agree with the above description, except that on sectioning the silver fir needles the fructification is seen to emerge through the stomatal opening and this does not appear to have been noted by the previous workers. The fungus was found on dead leaves in association with *Rhizosphaera Kalkhoffii*. Rostrup considered it non-parasitic and examination of the Scottish material confirms his conclusion.

Menoidea Abietis Mangin & Hariot.

Leaves of *Abies pectinata* bearing fructifications of *Menoidea Abietis* Mang. & Hariot, were collected at Inverary, Argyllshire in 1921 by Mr D. McIntosh, and by Mr W. H. Guillebaud in the Isle of Man in May, 1927. This fungus was first described by Mangin and Hariot (*Bull. Soc. Myc. France*, XXIII (1907), 65) from Jura, France, on leaves of *Abies pectinata*. The genus *Menoidea* was constituted for its reception. It was placed in the Tuberculariaceae-Mucedinaceae and thought to be probably a conidial stage of one of the Stictidaceae or Phacidiaceae. *M. Abietis* has not hitherto been recorded in Britain.

The fructifications of the fungus are very inconspicuous and can be seen on the dry leaf only as a slight elevation of the general surface level. They remain covered by the epidermis for a long time but at maturity the epidermal cells are usually completely cast off, when they measure from 300 to 400 μ in diameter. Colourless septate hyphae are abundant in the leaf tissue immediately under the fructification, which consists of a dense mass of hyphae bearing the layer of conidiophores on the surface (Pl. VIII, fig. 4). The conidiophores are hyaline, unbranched, septate (Mangin and Hariot figure non-septate conidiophores), 30 to 35 × 4 to 5 μ in size, each bearing a single conidium attached by its obtuse end (Pl. VIII, fig. 5). The difference in shape of the two ends of the conidium (not always clear) may become lost after it is shed. The majority of the conidia are unicellular but in some a transverse septum develops while still attached to the conidiophores. The conidia are usually curved but may occasionally be straight, and are 18 to 20 × 8 μ.

The Scottish specimens of *Menoidea Abietis* agree closely with the French description. They were found on dead leaves of *Abies pectinata* and there is no reason to suppose that the species is parasitic. The fructifications were accompanied by those of *Rhizosphaera Kalkhoffii*, while in the French specimens the associated species was *Rhizosphaera Pini*. We do not suggest that there is any close relation between the two genera, for the simultaneous occurrence of the species on the same leaf merely indicates similarity as regards their nutritive requirements.

We wish to record our thanks to Dr H. D. House of the University of the State of New York, U.S.A., to Professor Jaczewski of the Institute of Mycology, Petrograd for specimens and information regarding several of the species and to Miss E. M. Wakefield of the Royal Botanic Gardens, Kew for her valuable advice. A number of the specimens were received through the Forestry Commission.

EXPLANATION OF PLATE VIII.

Fig. 1. Pycnidium of *Rhizosphaera Kalkhoffii* on *Picea sitchensis*. ×about 300.
Fig. 2. Perithecium of *Phaeocryptopus Abietis* on *Abies Faxoniana*. ×about 420.
Fig. 3. Spores of *Toxosporium camptospermum*. ×about 900.
Fig. 4. Fructification of *Menoidea Abietis* on *Abies pectinata*. ×about 340.
Fig. 5. Conidiophores and conidia of *Menoidea Abietis*. ×about 750.

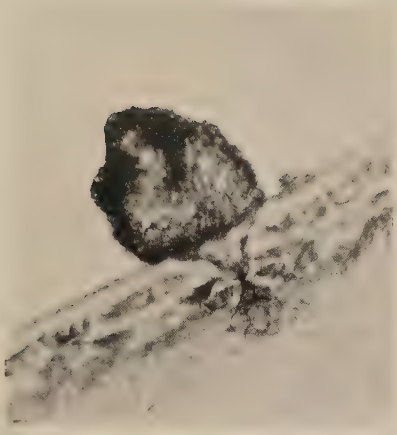
THE GENERA VERMICULARIA FR. AND COLLETOTRICHUM CDA.

By Maud M. Duke, B.Sc.

(With Plate IX and 11 Text-figures.)

THE need for an investigation into the morphology of the fungus genus *Vermicularia* has been apparent for some years. Many species have been removed from *Vermicularia* to other genera, chiefly to *Colletotrichum* and it has been doubted whether *Vermicularia* exists at all as a valid genus. As this question could be answered only by a critical study of the history and comparative morphology of the two genera, such a study has been undertaken and some of the results are recorded in the present paper. During the course of the work living material of as many species of *Vermicularia* as possible has been collected and grown in culture, and though subordinate to the primary object of the investigation, this work proved of sufficient interest to justify recording the observations in full.

The name *Vermicularia*, as applied to a genus of fungi, appeared for the first time in Tode's *Fungi Mecklenburgenses Selecti* in 1790. The accompanying description (I. 31) showed it to be a fungus with a globose sessile "capsule" containing free vermiculate "seeds." Three species were given, *V. pseudosphaeria*, *V. pubescens* and *V. hispida*. Of these the first two, according to their descriptions and figures, did not possess fruit bodies with hairy appendages. *V. hispida*, however, as its name implies, had a "perithecium" covered with setae (*loc. cit.* Tab. VI, figs. 46–8), and for this reason is more comparable with the modern idea of *Vermicularia*. The presence of hairs on the fruit



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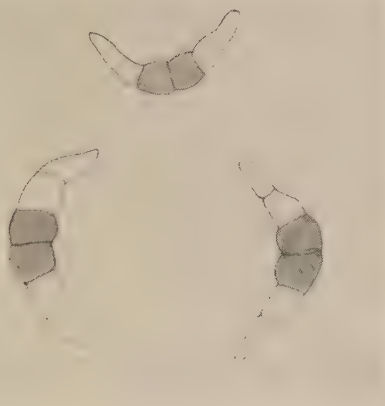

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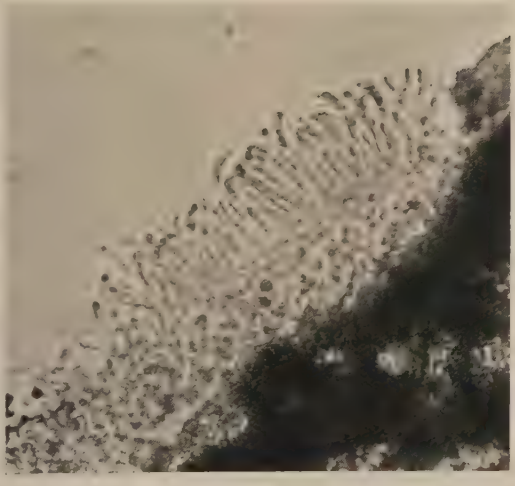

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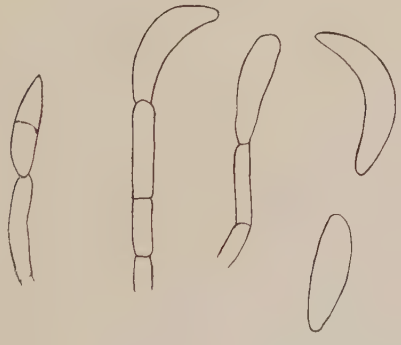

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body was apparently not regarded as an essential character of the genus.

Being unfamiliar with Tode's new genus, Persoon (2) quoted the original descriptions, but added a note casting doubt on the three original species, and even questioning the inclusion of the genus in the order in which it was placed.

In 1817 Nees (3) queried if his *Sphaeria Vermicularia* could be the same as Tode's *V. hispida*.

The next writer of note to deal with the genus was Fries, and since, according to the International Rules (4), the nomenclature of this group of fungi dates from Fries's *Systema Mycologicum* (5), it is this writer and not Tode who has to be regarded as the founder of, and the authority for, the genus *Vermicularia*. It is important therefore, to obtain as clear an idea as possible of his conception of the genus.

In 1825 Fries ((6) p. 111) included it in the Sphaeriacei. According to his definition of the Pyrenomycetes, and his generic description, *Vermicularia* was a fungus possessing a closed fruit body or "perithecium." This was depressed, astomous, and its dehiscence occurred by a split. The distinguishing feature was the presence of setae on the "perithecium." This defines clearly what he considered was the form of the fruit body. The contents consisted of "asci (or sporidia)" which were "annulate, vermiculate." In 1849 Fries quoted the genus "*Vermicularia* Fr. S.O.V. nec Tod." and placed it in a division of the Pyrenomycetes which he called the Coniomycetoideae. The inclusion of what is now known to be an imperfect fungus in the Pyrenomycetes, and the statement that *Vermicularia* possessed asci or sporidia, necessitate some explanation of Fries's group of Pyrenomycetes.

The members of this division are characterised according to Fries by the possession of a closed "receptacle," the perithecium, inside which the spores are produced. These are endogenous or "reduced to sporidia." All Pyrenomycetes are, Fries concludes, from a "rarely failing faith in the constancy of Nature," typically ascigerous fungi. There are, however, members of the group in which asci are absent, while in others they are "reduced to sporidia." Thus in *Diplodia*, etc. the *sporidia* are not *spores*, but *asci* which have been reduced to sporidia. The evidence on which he based this hypothesis is that in their situation, mode of origin, form and function, these "sporidia" correspond to asci rather than to spores, which are borne free in a cellular vessel (ascus); "sporidia" are pedicellate and "adnate" as asci, not like free spores. Holding this view of the relation of asci and sporidia, namely that the latter are merely reduced forms of the former, it is not possible, Fries said, to distinguish genera

or even species on the grounds of the presence or absence of asci. This interesting view explains why Fries placed *Vermicularia* and other such fungi in the Pyrenomycetes.

Thus it is obvious that Fries in 1849 did not differentiate between Pyrenomycetes and Sphaeropsidaceae, although he realised their structural difference. His views on the taxonomy of the genus in question were therefore somewhat curious. As regards the morphology of the fungus, he believed it to possess a closed fruit body, containing not asci, but "sporidia" which represented reduced asci. The further characters of the genus as determined by him, were that the perithecium was astomous and provided with setae, and that the sporidia were septate.

The first work of Fries in which *Vermicularia* appeared was *Systema Orbis Vegetabilis*, published in 1825. Here in addition to Tode's original three species, the following papillate *Sphaerias* were included in the genus: *S. comata*, *S. capillata*, *S. Dematium*, *S. Vermicularia*, etc.

In 1828 Fries (9) amplified this, and stated that on account of the nature of the perithecium, ostiole, and asci in *S. Dematium*, *S. trichellum*, etc., he would remove these from the genus *Sphaeria*, and form a separate genus, which, with Tode, he would call *Vermicularia*.

Finally Fries (7) adopted the name "*Vermicularia* Fr. nec Tod." In a footnote, he disposed of Tode's three species as being not fungi, or of exceedingly doubtful relation, and substituted his own genus for Tode's, keeping the old name, as it has already become familiar to a certain number of people. The genus here contained twelve species. Five* of these had previously been included under *Sphaeria*, three† under *Exosporium*, and the remaining four‡ were described for the first time as *Vermicularia* spp.

S. comata, *S. capillata* and *S. Vermicularia* later proved to be true ascus-bearing fungi, so that of the species originally regarded as *Vermicularia*, the only one which has retained its position in the genus is *V. Dematium*. Therefore *V. Dematium* should be regarded as the type ("standard") species of the genus, which is in agreement with Diedicke's views (8).

Since Fries's time the genus *Vermicularia* has been accepted as laid down by him. Its systematic position was not fixed until Fuckel created the group of Fungi Imperfecti (10), in which he included *Vermicularia*. Most mycological writers follow Fries and even the authors of the standard systematic works of the

* *V. epixyla*, *V. Dematium*, *V. relicina*, *V. ditricha*, *V. trichella*.
† *V. maculans*, *V. hypodermia*, *V. hispidula*.
‡ *V. protracta*, *V. culmifraga*, *V. culmigena*, *V. punctiformis*.

present day, Saccardo (11), Allescher (12), Diedicke (8), etc. have placed *Vermicularia* in the Sphaeropsidales.

During the last few years, mycologists who have had occasion to work with various species of *Vermicularia*, have realised that some of these are not true *Vermicularias* in the sense of Fries, since they have no trace of a pycnidium. Such discoveries have necessitated removing these species to some other genus, and the genus which has best met the case is *Colletotrichum*. Thus Walker (13) from a study of *V. circinans* supported Voglino (14) in transferring *V. circinans* Berk. to *Colletotrichum*. A similar fate has overtaken several species of *Vermicularia*, and the question arises whether there exists a true *Vermicularia* sensu Fries.

Desmazières seems to have been the first to doubt the presence of a pycnidium in any one species of *Vermicularia*. In a note accompanying *Exosporium minutum* Link var. *Hederae*, specimen no. 1848 of his Exsiccatae (15), Desmazières said he adopted the generic name *Exosporium* for *Vermicularia trichella*, *V. macrochaeta*, and others, because these species did not possess a "perithecium," but a stroma, and their hymenium was superficial.

Fuckel (10), enumerated six species of *Vermicularia*, amongst which were *V. Dematium* and *V. trichella*. He remarked that there was no true "perithecium" in any of the species, but a "stromatic tubercle" on which the setae and conidiophores were borne. Realising the difference between his conception of the genus and that of Fries, Fuckel renamed it "*Vermicularia* Fckl. non Fr.," and classified it in the Gymnomycetes, a class apparently corresponding to the Tuberculariaceae.

Saccardo (11) included *Vermicularia* in the Sphaeropsidaceae but remarked that the genus required investigation since certain species possessed "imperfect or pezizoid perithecia" and therefore should be transferred to *Colletotrichum*. *V. Dematium* Fr., *V. ambigua* Sacc. and *V. Liliacearum* West. were specified as of this type.

Potebnia (16) suggested splitting the Sphaeropsidales into two groups, the Pycnidiales containing such forms as *Phyllosticta*, *Phoma*, etc. which give rise to true pycnidia; and the Pseudopycnidiales including genera like *Septoria* and *Vermicularia* characterised by incomplete pycnidia.

Von Höhnel (17) suggested transferring *Vermicularia* to the Tuberculariaceae.

Diedicke (8) placed *Vermicularia* in the pycnidial group of the Sphaeroideae but remarked that it was incorrectly placed here, since he agreed with Fuckel's statement that a true pycnidium was absent. He thought with von Höhnel (17) that its proper taxonomic position was in the Tuberculariaceae.

In 1923 von Höhnel's new classification of the Fungi Imperfecti (18) removed *Vermicularia* from all pycnidial relationships and placed it in the Tuberculariaceae.

Finally Archer (19) has recently expressed the view that "there is no good reason for retaining the genus *Vermicularia* as separate from *Colletotrichum*." He reaches this conclusion 'from the study of the morphology of the two species *V. circinans* and *V. Peckii* compared with the descriptions and illustrations of various species, and with a number of exsiccati."

The above is a selection only of the opinions of those who have written critically on *Vermicularia*. Several others have removed, or would recommend removing, species from this genus to *Colletotrichum, e.g.* Briosi and Cavara (20), Grove (21), Walker (13), Dickson (22).

Thus almost from the very date of its foundation, there has been doubt and dissatisfaction as to the status of the genus.

The Systematic position of *Vermicularia*.

The answer to the question whether there is a pycnidial genus *Vermicularia* could only be obtained by a complete revision of the genus. With this end in view more than twenty species of *Vermicularia* have been critically examined, with the result that no evidence of a pycnidium has been found. Further, examination of Fries's own material of *V. Dematium* (Scler. Suec. No. 202), showed that no pycnidium was present. Sections of the pustules showed a fairly large, dark brown, erumpent, setose, pulvinate stroma, whose uppermost portion was differentiated as a palisade-like layer of conidiophores bearing conidia (Pl. IX, fig. 2) and the conclusion was reached, that Fries mistook the dark cushion-shaped stroma for a pycnidium. Examination of Persoon's and other material of the same species revealed a similar structure. There is, it is considered, sufficient evidence to show that the genus is not Sphaeropsidaceous.

The question therefore arises, what is the proper place of this genus in a modern classification? According to the arrangement of the Fungi Imperfecti in general use, there are two groups in which *Vermicularia* might be placed, the Melanconiaceae and the Tuberculariaceae. The characters of the first are described concisely by von Höhnel (23) as follows: "Unter Melanconieen verstehe ich nur solche gehäuselose Conidienpilze, die noch im Substrate eingeschlossen Sporen bilden, durch deren Entwicklung erst die Decke gesprengt wird." The essential feature of the Tuberculariaceae on the other hand is that the cushion-like stroma is superficial, and the spore-producing layer is exposed from its initiation. There is a close similarity between the adult forms of many members of the two groups. Both show a stro-

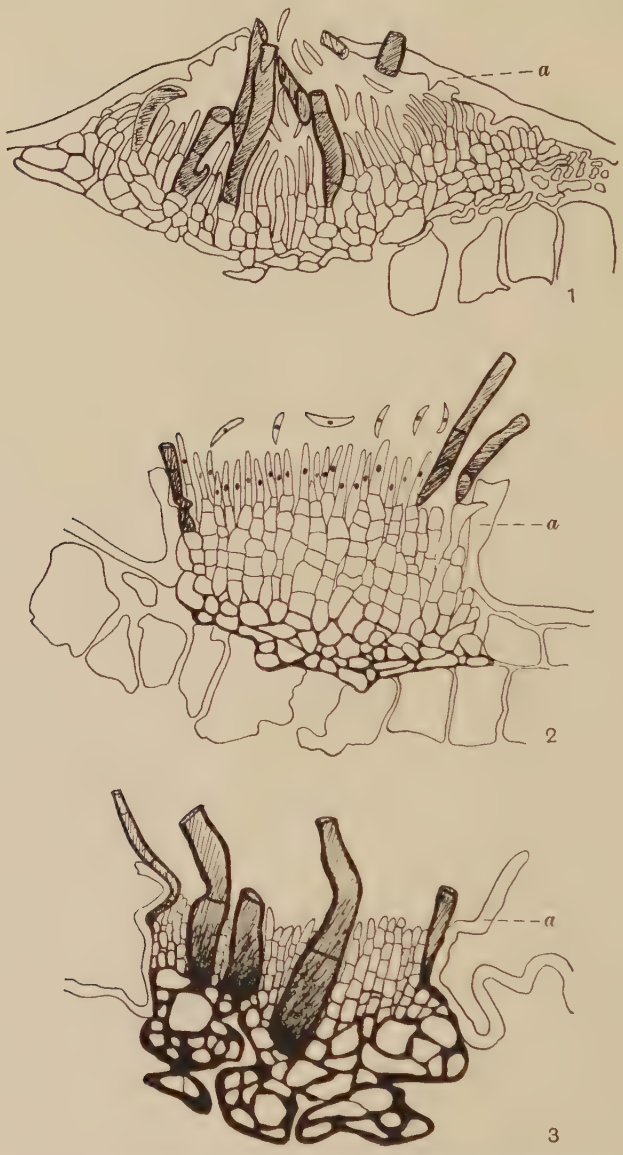
matic structure developed to a greater or less extent, bearing conidiophores on its upper surface. The distinction between such forms is purely developmental; in the Melanconiaceae the spore-producing layer is innate, afterwards becoming erumpent, while in the Tuberculariaceae the same layer is superficial from the first.

As regards the genus in question, examination of several species has led to the conclusion that *Vermicularia* belongs to the Melanconiaceae. Serial microtome sections of young acervuli have shown that the spores may be initiated and sometimes completely formed under the cuticle (Text-fig. 1). This subcuticular development of the spores, however, is often masked when the setae develop quickly and pierce through the overlying tissue before the conidia are properly formed.

Detailed description of *Vermicularia*.

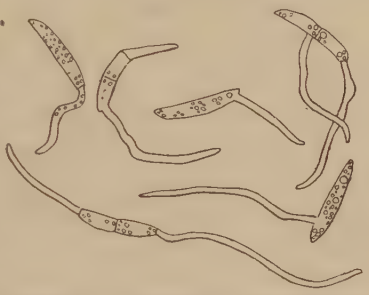
All species of *Vermicularia* have a characteristic appearance; the substrata on which they grow are covered with small, slightly raised, black dots, the acervuli. These, if carefully examined, are seen to be thickly covered with minute black hairs, which are sometimes visible to the naked eye. The circular or oblong acervuli are initiated below the cuticle or epidermis, by the concentration of hyphae at certain points. As the hyphal mass enlarges, a small convex or broadly conical cushion is formed, covered by the cuticle which becomes pushed up by the abnormal growth, and especially by the young developing setae which elongate rapidly and at length pierce the cuticle (Text-fig. 1). Further growth of the acervulus results in its pushing aside the now ruptured cuticle, and becoming free (Text-fig. 2). The torn cuticle is retained more or less like a frill around the stroma. The setae thus serve to penetrate the cuticle, so that the spore-bearing layer may become superficial, and the spores be successfully distributed.

The following description is based on Fries's material of *V. Dematium*, on *V. trichella*, and on several other species. In transverse section (Text-fig. 2; Pl. IX, fig. 2), the acervulus shows a basal stromatic portion varying in thickness with irregularly arranged cells having thick and blackened walls. This region gives place above to one in which the cells are more regularly arranged in vertical series, with cell walls thinner, and not heavily blackened. The uppermost cells here consist of conidiophores, simple hyaline cylindrical structures, each bearing one conidium at its tip. Scattered around and through the acervulus are the setae which have their origin in the basal or middle layers of the stroma, and extend as far as and beyond the surface of the acervulus. They are more or less straight,



Text-figs. 1–3. *Colletotrichum trichellum*, transverse sections of acervuli: 1, young acervulus showing subcuticular development of spores, and rupture of cuticle by the setae; 2, mature sporing acervulus; 3, older acervulus in sterile sclerotial stage. 1 and 2 on Ivy leaf, 3 on Ivy petiole. *a*, cuticle of host. ×445 approx.

rigid, brittle, thick-walled, usually with a subulate base. Although quite black to the naked eye and under a lens, they appear brown under the microscope, become paler towards the apex, and are paler when young. They are septate, but when mature the septa are sometimes difficult to discern owing to the dark colour. They have been found up to 400μ long and are 5–12μ broad at the base, gradually tapering to a more or less acute apex. The spores are simple, hyaline, fusoid, straight or slightly curved, with sub-acute ends, one of which is sometimes more pointed than the other. Staining with cotton blue or Weigert's haematoxylin shows up a deeply stained circular portion in the centre; this appears to be the nucleus. Living spores usually contain a number of oil globules, irregular in size and position. Spores have been measured from 14–30μ in length (when mature generally 20–28μ), and 3–5·5μ in breadth. Fries (7), and Fuckel (10) described the spores as septate, but in no species examined by me were septate spores found. When spores of *V. trichella*, however, were germinated in hanging drop cultures, it was seen that just before germination a median septum appears in some spores, and later a germ tube is put out from either or both of the two newly formed cells (Text-fig. 4). Pethybridge (24) has described a similar occurrence in *V. atramentaria*, and Walker (13) in *V. circinans*. Spores present in Fries's material were found to be continuous with a deeply staining portion in the centre. Fries, with the inferior magnifying instruments available in his time, may have mistaken this nucleus for a septum, or he may have chanced upon spores about to germinate with the median septum developed.



Text-fig. 4. Spores of *Colletotrichum trichellum* germinating in hanging drop culture, eighteen hours after inoculation. ×445 approx.

Briefly, the three chief characters of the genus *Vermicularia* as seen in *V. Dematium*, etc. are the stromatic acervulus with no sign of a pycnidium, the dark coloured setae, and the continuous elongated fusoid spores.

Comparison of *Vermicularia* with *Colletotrichum* Cda.

In the Melanconiales, Potebnia's (16) Acervulales, or von Höhnel's (18) Stromaceae, the only genus which shows the three distinguishing features of *Vermicularia*, and which therefore can be compared with it, is *Colletotrichum* Cda.

This genus is in general characterised by a flattened disc-shaped or oblong fruit-body surrounded by, or beset with, dark setae. It is innate at first but later becomes erumpent. In transverse section the mature acervulus shows a stromatic layer which is usually flat, but with considerable variability in thickness. On the upper surface is the hymenial layer, consisting of upright, cylindrical, hyaline conidiophores, each bearing on its tip one conidium. The only other elements in this superficial layer are the setae, which originate in the basal layer of the stroma, and project beyond the surface as stiff bristles. They are thick-walled, septate, dark brown to black, paler at the apex, so that the tips are sometimes quite hyaline. Their most obvious function appears to be piercing the cuticle of the epidermis and allowing the spore-producing layer to become free, or partly so, as in *Vermicularia*. The presence of setae in certain species of *Colletotrichum* is now well known to be a variable character, such species as *C. lindemuthianum* and *C. oligochaetum* showing hairs at one time, and not at another. The conidia are of two types throughout the genus. In *C. lineola*, *C. Andropogonis*, etc. they are continuous, hyaline, fusoid, straight or slightly curved, and somewhat pointed at the ends, *i.e.* identical with the spores of *Vermicularia*. In *C. lindemuthianum*, *C. gloeosporioides* and others they are cylindrical, straight, with rounded ends, and varying in size.

Comparing this description with that of *Vermicularia*, it is evident that the two genera resemble one another to an extraordinary degree. The possible points of divergence seem to be the amount of stromatic tissue developed, the scarcity or lack of setae in some *Colletotrichum* species, and the difference of spore shape of some members of this genus. *Vermicularia* is generally associated with a thicker, more stromatic, acervulus than *Colletotrichum*. This is a relative character, and moreover very variable. In *V. trichella* on Ivy I have found flat *Colletotrichum*-like acervuli, while Ivy leaves kept in a damp chamber for some time produced much thicker acervuli with well developed stromatic bases, the whole effect being, at first sight, like a Tuberculariaceous fungus. In several species, *e.g. V. Dematium*, *V. Eryngii*, *V. Liliacearum*, *V. Holci*, it was found that towards the end of the sporing period, *i.e.* at the beginning of winter, a large amount of stromatic tissue had been produced externally, or internally in the host cells, converting the original fairly flat acervulus into a thick sclerotium (Text-figs. 3 and 9–11) which appears to be capable of bearing spores the following season. The relative development of this sclerotic base appears then to be partly a matter of age and partly of environmental conditions, and cannot be regarded as a diagnostic character to separate two genera.

The scarcity or occasional lack of setae is well known in certain species of *Colletotrichum*. When the hairs are present, even in small numbers, the fungus exhibits the essential characteristics of this genus. When they are absent, it might be identified as *Gloeosporium*. The intimate connection of these two genera is thus evident; but the actual relationships of one to the other, whether *Colletotrichum* should be made a sub-genus of *Gloeosporium* as Krüger (25) has recommended, is outside the scope of this paper. It is suggested that too much weight should not be placed on forms with few, or at times, no hairs; they may be looked upon as transition species. On the other hand, forms which possess conspicuous setae are many, *e.g. C. anonicola*, *C. Anthurii*, *C. falcatum*, *C. Malvarum*, etc. Moreover, this difference, if such it be, between *Vermicularia* and some species of *Colletotrichum* when carefully examined, is one only of degree, and seems altogether too slight to be made a distinguishing character of the two genera.

Also, there is the difference in spore shape. This character is useless as a means of generic distinction, since such typical Vermiculariae as *V. atramentaria* and a new species to be described below (p. 178), have straight spores; and unquestioned Colletotricha as *C. falcatum*, *C. Andropogonis*, etc. have curved spores.

The three possible characters separating *Colletotrichum* generically from *Vermicularia* having been shown to be untenable, there is no valid reason for regarding *Vermicularia* and *Colletotrichum* as separate genera.

The history of *Colletotrichum* provides a clue to the relation of the two genera, and shows how the misconception arose. *Colletotrichum* as a genus was described first in 1837 by Corda, and contained one species, *C. lineola*, which was figured. This species, therefore, is the type species of the genus. According to Corda's description, *C. lineola* is characterised by a linear acervulus; fusiform, curved, acute, hyaline spores; and dark, opaque, subulate setae. It was found on Umbelliferous stems in late autumn, near Prague. This description recalls that of any *Vermicularia*, while the host plants, and season when it was found, remind one more especially of *V. Dematium*, which was described as "commonly on the dried up stems of herbaceous plants in winter" (5). Moreover, Corda's diagrams of *C. lineola* have been compared with Fries's material of *V. Dematium*, and the spore shape is almost identical. No spore size is given by Corda, but Saccardo (27) later gave the measurements of the same species as 25–28 × 3·5–4μ, while Fries's own material yielded spores of slightly smaller size, 20–24 × 3·5–4·5μ. This discrepancy is too small to be of any great significance, and may

be due to difference of hosts*. In his description of *C. lineola*, Saccardo (*loc. cit.*) recognised its similarity to *Vermicularia*, and remarked that it seemed to be a young stage of *Vermicularia*, lacking a perithecium.

From this comparison it is possible and even probable that the genera *Vermicularia* and *Colletotrichum* were based on the same fungus, *i.e. V. Dematium* = *C. lineola*. Fries, in 1825, labouring under a misapprehension, thought the fungus was pycnidial and called it *Vermicularia*; Corda in 1837 realised the true Melanconiaceous structure and called it *Colletotrichum*. Thus arose the misunderstanding which has persisted to the present day.

From the historical evidence, and from a general comparison of the two genera, the proposal put forward above seems to be therefore fully justified.

At the present time very little is known of the perfect stages of these fungi, and although I kept four species of *Vermicularia* in culture for nearly two years, nothing further was discovered. This is another point in favour of combining *Colletotrichum* and *Vermicularia*, at least until their perfect forms are better known.

Nomenclature.

The question of which name to apply to this combined genus remains to be dealt with. The correct procedure according to the rules of nomenclature would be to adopt the older name *Vermicularia* (6) and drop *Colletotrichum* (26). This would involve a considerable amount of confusion, particularly among pathologists, since many well-known diseases are caused by species of *Colletotrichum*. To rename all these would give rise to a complex situation, especially as many have already been transferred from *Vermicularia*. Further, the genus *Colletotrichum* is more widely known than *Vermicularia*. For these reasons, it seems advisable to suggest that the name *Colletotrichum* Cda. be placed on a list of nomina conservanda, and to adopt it in place of *Vermicularia* as involving less confusion.

The genus *Volutella* Fr.

No study of the taxonomy of *Vermicularia*, or *Colletotrichum*, can be complete without reference to another genus which is characterised by the presence of setae. Confusion between *Volutella*, *Vermicularia* and *Colletotrichum* has often arisen. Dickson (28), in identifying the organism of Black Dot disease of potato, for instance, could at first only place it in the "*Colletotrichum-Vermicularia-Volutella*" group.

* Saccardo's measurements are from specimens on *Andropogon gryllis*.

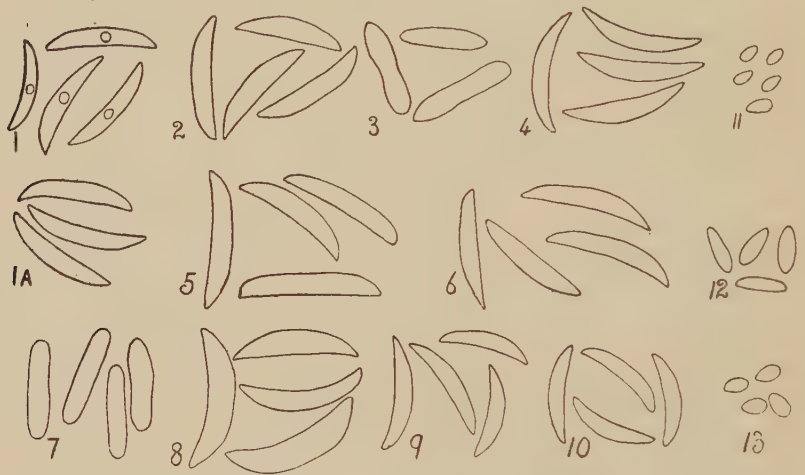
Examination both of its history, and of a considerable number of specimens of *Volutella*, have led to the conclusion that this is a valid genus distinct from *Colletotrichum*.

The genus *Volutella* was created by Tode (1) and his first species *V. volvata* which is the type species, is light in colour, becoming "fulvous or flavofuscous" when old. Fries (5) also regarded it as pale coloured, and to the present day the genus has generally been associated with a light coloured sporodochium, surrounded by, or beset with, hyaline or pale coloured setae. Certain species with dark or black setae have been referred by various mycologists to this genus, but a careful examination of such plants would probably result in their being removed to *Colletotrichum*. A case in point is *V. cyperacearum* Ces., already declared a doubtful species by Lindau (12). As far as could be determined from the rather scrappy sterile co-type material in Herb. Kew., the specimen is indistinguishable from *Colletotrichum* in its sclerotial characters and dark septate setae. Similarly from Stoneman's descriptions and figures, *V. Violae* Stonem. ((29), Figs. 85–89), and *V. citrulli* Stonem. (Figs. 80–82), are apparently true *Colletotrichum* spp. Of other species with dark setae, *V. aciculosa* (E. & H.) Sacc. is neither a *Volutella* nor a *Colletotrichum*, but a pycnidial fungus with acicular spores. No definite decision can at present be given about *V. Dahliae* Oud., *V. tristis* v. Höhn., *V. cucurbitina* Peck, *V. Acalyphae* Atk., *V. oxyspora* Atk. and *V. Allii* Patters., because no material or figures have been available for examination, but from the original descriptions it seems that these species would be more correctly placed in *Colletotrichum*. It is significant too, that all the above so-called *Volutella* spp. possess large spores much like those found in *Colletotrichum*.

Other possible criteria of generic difference between *Volutella* and *Colletotrichum* are the initial position of the hymenial layer relative to the host; and the spore characters. *Volutella* is a superficial fungus (*e.g.*, *V. ciliata*), and its hymenium is superficial from its inception. In *Colletotrichum* on the other hand, the hymenial layer is initiated underneath the epidermis or cuticle of the host, and becomes free only by the rupture of the covering tissue. *Volutella* is thus a typical Tuberculariaceous genus, while *Colletotrichum* must be classified in the Melanconiaceae. The final form of the fruit-body in *Volutella* is pulvinate, spherical or shortly stipitate. This genus is generally associated with a much more developed stroma than *Colletotrichum*. This alone, as a diagnostic character is of little use, for as stated above, *Colletotrichum* spp. have been found with well developed, pulvinate, *Volutella*-like stromata.

Spore shape and size are likewise in themselves not satisfactory

characters for generic distinction, but when differences in spore shape and size are correlated with differences in other characters, the evidence for generic difference becomes more convincing. The type of spore characteristic of the genus *Volutella* is a small, straight, oval or oblong one, varying in length from 4 to 14μ (Text-fig. 5, 11–13). The spore typical of *Colletotrichum* is oblong or fusiform, straight or curved, and generally about 11–28μ in length (Text-fig. 5, 1–10).



Text-fig. 5. Spores: 1, *C. Dematium*, Fries's material; 1 *A*, *C. Dematium*, fresh material on *Carum Carvi*; 2, *C. Eryngii*; 3, *C. atramentarium*; 4, *C. Liliacearum*; 5, *C. trichellum*; 6, *C. Lysimachiae*; 7, *C. Wahlenbergiae*; 8, *C. Holci*; 9, *C. circinans*; 10, *C. chaetostromum*; 11, *Volutella ciliata*; 12, *V. Buxi*; 13, *V. setosa*. All ×685 approx.

In short, *Volutella* is a superficial fungus with a white or pale coloured sporodochium provided with hyaline or pale coloured setae, and producing small oval or oblong spores. *Colletotrichum* on the other hand, is an erumpent fungus, with a dark acervulus bearing dark brown setae and large oblong or fusiform spores.

The fusion of *Vermicularia* with *Colletotrichum* necessitates a revision of the species of the two old genera. There are at present about one hundred and sixty species of *Vermicularia* and probably more of *Colletotrichum*, so that the possibility of reducing the number of species should be borne in mind. A great deal of simplification in this direction could doubtless be achieved. It is only natural that the same fungus should have been described under both genera. A preliminary species grouping on the basis of host plants could be carried out, and a more critical one on morphological characters should follow. Further, cross-inoculation experiments would probably give evidence

for the elimination of a certain number of structurally similar species. This is indicated by the fact that the Ivy *Vermicularia*, now *C. trichellum*, has been reported on such widely different hosts as *Magnolia*, *Salix*, *Smilax*, *Arum*, *Pyrus*, *Acer*, and *Castanea*. The writer inoculated leaves of *Quercus Ilex*, through wounds, with a spore suspension of *C. trichellum* from Ivy. Within a few days definite brown circular infected areas developed, and later, fructifications of *C. trichellum* were produced. Control leaves developed no fungus.

Notes on Some British Species of *Vermicularia*.

1. ***Colletotrichum Dematium*** (Fr.) Grove in *Journ. Bot.* LVI (1918), p. 341.
   Vermicularia Dematium Fr. *Summa Veg. Scand.* p. 420, 1849.

Fresh material in a freely sporing stage has not been found, but older sterile sclerotial stages were procured on *Heracleum* at Howth near Dublin in September 1925, and in October 1926 younger stages with a limited number of spores were found on *Carum Carvi*, *Monarda fistulosa*, and *Meum athamanticum* in Kew Gardens. These specimens agreed well with Fries's material of this species. The fungus is found low down on the dead stems, generally just above the level of the soil and extending upwards for a few inches or more. The attacked area is covered with very numerous small black hairy sclerotia. The acervuli found in these specimens are erumpent, round or oblong, sometimes confluent, up to 300μ in diam., black to the naked eye, in section under the microscope brown, consisting of irregular thick-walled cells, forming a pulvinate cushion surrounded by the torn cuticle. Arising from all over and around the disc are the setae which are cylindrical, rigid, brittle structures, straight or slightly bent, thick-walled, septate, swollen at the base, more or less acute at the apex, dark brown, becoming paler towards the apex, and paler when young. Owing to the opaqueness of the mature setae, the septa are difficult to distinguish. They vary in length from about 50–400μ and are about 6–12μ broad at the thickened base. The conidia are borne one at a time at the apex of cylindrical conidiophores, and are fusoid, straight, or slightly curved, 20–25 × 3·5–4·5μ averaging 22 × 4μ (Text-fig. 5, 1 and 1 *a*).

After sporing the acervulus apparently penetrates further down into the host tissue and gives rise to a large definite brown sclerotium consisting of large irregular cells below, smaller above, and a palisade layer of regular cylindrical cells at the surface, and the whole covered with setae. This appears to be

a winter resting stage. Sclerotia lower down in the host tissue, and quite distinct from those on the surface are also found, as has been described by Ducomet (30) for *C. atramentarium*.

C. Dematium has been regarded as the commonest species of the genus, but in my experience, others occur more frequently. Unfortunately it has not been found possible to obtain pure cultures from the material available, and consequently a comparison of cultural characters could not be made. It is probable that other species of the old genus *Vermicularia* recorded on dead herbaceous stems are identical with this one, but in the absence of cross-inoculation tests, no definite statements can be made. This aspect of the work will, it is hoped, be taken up later. The possibility that *C. lineola* Cda. is the same species has been mentioned above (p. 166).

2. ***Colletotrichum Eryngii*** (Desm.) Duke nov. comb.
Vermicularia Eryngii Desm. *Pl. Crypt. Fr.*, sér. 1, no. 542, 1825–51.

This species has previously been cited as *V. Eryngii* (Cda.) Fuck. The correct citation is however, *V. Eryngii* Desm., since Desmazières used the name between 1825 and 1851, and Fries in the Index to the *Systema*, published in 1832, listed *V. Eryngii* Desm. This places the date of Desmazières' publication of the name at 1832 or earlier. Both Corda and Fuckel are, of course, later than this.

Fresh fertile material was found on three cultivated species of *Eryngium*: *E. giganteum*, *E. Oliverianum* and *E. Sanguisorba* in Kew Gardens in September 1926, and older sterile stages on *Eryngium* sp. in October 1925. The position and appearance to the naked eye of this species is similar to that of the previous one, with the addition that acervuli were found much higher up on the stem. Herbarium specimens show that they may occur also on the leaves and petioles. Microscopic comparison of this species with *C. Dematium* shows that there is so little difference between them, that on morphological characters alone they can hardly be regarded as specifically different. The spores are similar in shape, and vary in size from 18–25 × 3·5–4·5 μ averaging 21 × 4 μ (Text-fig. 5, 2). Sterile winter sclerotia are also found.

In culture this species gives definite colour reactions. In single spore cultures on Dox's agar from pustules on *E. giganteum*, a rose-pink colour (Alizarine Pink*), developed in four to five days, spreading as the individual enlarged. This coloration is due to the development of a pigment in the medium. After

* All colours are described according to Ridgway's Colour standards and Nomenclature, 1912.

five to six days dark brown to black sclerotia appear in the centre of the culture, in a stellate arrangement; later they arise irregularly all over the surface (Pl. IX, fig. 3 *A*). After six to eight days aerial mycelium of a greenish gray colour (light Olive Gray to Olive Gray), becomes noticeable, and the first bright pink colour begins to fade to a purplish tinge. On the eleventh day the colour was Rocellin Purple. When the culture becomes three or four months old, the mycelial groundwork is Pale Mouse Gray, with a slight pinkish tinge shining through, and the whole surface is dotted with small black sclerotia. In successive subcultures the production of pink colour gradually lessens. One multispore culture on the same medium developed spore pustules in eight days, and this was the only tube which produced conidia.

It is obvious that the Kew material is a different strain of *C. Eryngii* from that recently described by Killian (31). He used various synthetic and other media, but does not mention a pink colour. Further, in all his cultures he failed to obtain spores. That the strain may vary according to the species of the host is indicated by the much duller pink colour, and quite different general appearance developed on the same medium and under the same conditions by material from *E. Oliverianum*. No morphological differences between the strains on *E. giganteum* and *E. Oliverianum* were observed, but spores from *E. Sanguisorba* proved to be very slightly larger than the other two strains. Further work on the strains of *C. Eryngii* and their cultural characters is necessary.

Since the cultural characters of *C. Dematium* have not yet been determined, it is impossible to decide whether *C. Eryngii* is actually distinct from it or not*.

* Since the above paper was written *C. Dematium* has been obtained in pure culture from dead Lupin stems. The similarity in morphological structure, between this species and *C. Eryngii*, is rendered more striking by their cultural behaviour. *C. Dematium* produced a beautiful rose-pink colour on Dox's agar, and finally gave rise to cultures whose grayish colour and general aspect were almost identical with those of *C. Eryngii*. The only difference seemed to be in the size, initial distribution and time of appearance of the sclerotia. In *C. Eryngii*, these began to appear in a stellate arrangement after about three to four days, and in a thirty days old culture were scattered irregularly all over the surface (Pl. IX, fig. 3 *A*). In *C. Dematium* the sclerotia did not start to develop until the cultures were nineteen or more days old, were scattered with no definite initial arrangement, and in a thirty days old culture they appeared scattered as in *C. Eryngii*, but were much fewer, and longer than formerly. Such minor divergences do not seem to merit specific difference.

Further, if *C. Dematium* occurs on all kinds of herbaceous plants, especially on Umbelliferae (11), it is likely also to occur on *Eryngium*.

The morphological characters, the cultural behaviour on the same medium, as well as the nature of the host plants, all agree so well that it is considered that *C. Eryngii* can only be a strain of the older species *C. Dematium*.

3. ***Colletotrichum atramentarium*** (B. & Br.) Taub. in *Mem. N.Y. Bot. Gard.* VI (1916), p. 554.
Vermicularia atramentaria B. & Br. in *Ann. Nat. Hist.* ser. 2, V (1850), p. 378.

So much has been written about this species, the causal organism of Black Dot or Dartrose disease of Potatoes, within recent years, that it is unnecessary to add much here. Descriptions of the fungus have been provided by Pethybridge (24), Bewley and Shearn (32), and Dickson (33). The synonymy of the species is found in the last named paper. The amethyst coloration in cultures is interesting, on account of the parallel production of a red pigment by *C. Eryngii*. *C. atramentarium* differs from all other *Vermicularia* spp. examined, with the exception of *C. Wahlenbergiae*, in having straight cylindrical (cigar-shaped) (Text-fig. 5, 3), instead of fusiform and more or less curved conidia.

4. ***Colletotrichum Liliacearum*** (West.) Duke nov. comb.
Vermicularia Liliacearum West. in *Prod. Fl. Batavae*, II, 4 (1866), p. 113.

Material was found on dry scapes of *Scilla nutans* in October 1925 and again in September 1926 in Queen's Cottage Grounds, Kew Gardens. A considerable area of the shiny white stems, from the soil level upwards, was covered with the characteristic black setose acervuli. The first collection was sterile and consisted of black sclerotia similar to those termed winter sclerotia in the descriptions of the previous species. The material found the following year was sporing freely and cultures were obtained. Squash preparations and sections of the acervuli revealed the same structure as described for *C. Dematium* with spores more regularly curved, $21–26 \times 3{\cdot}5–4{\cdot}5\mu$, with $24 \times 4\mu$ as an average size (Text-fig. 5, 4). After the production of spores the stroma seems to enlarge as in the previous species, and give rise to a sterile winter sclerotium.

Single spore cultures on Dox's agar showed, after four or five days, a white cob-webby growth. Three days later this became black at the centre, and gradually the dark colour spread all over the plant. Finally the upper surface of the culture took on a grayish colour (Mouse Gray), while underneath it was quite black (Pl. IX, fig. 3 *C*). Sclerotia were formed on the preliminary gelatine plates and in some of the multisporous cultures, and spores were developed in some plates and tubes. Occasionally in multisporous cultures the surface of the slant became concentrically zoned, a deep black, shiny, flat zone alternating with a gray, felty zone. Such zoning disappeared when the cultures were three to four months old, and the colour became a perfect

neutral gray not matched in Ridgway. On malt and meat gelatine the cultures remained white but on Dox's agar they became gray-black.

5. ***Colletotrichum trichellum*** (Fr.) Duke nov. comb.
Vermicularia trichella Fr. in *Grev. Scot. Crypt. Fl.* II, t. 345, 1824.

Material of this species was first found on Ivy leaves in Kew Gardens in November 1924. Afterwards it was procured frequently at Kew (various dates); Devon (E. M. Wakefield, May 1925); Howth, Dublin (September 1926); near Hereford (September 1926); and near Iver, Bucks. (October 1926). It has been found in fact nearly every time it has been looked for, and generally on Ivy growing along the ground. It obviously is of fairly frequent occurrence.

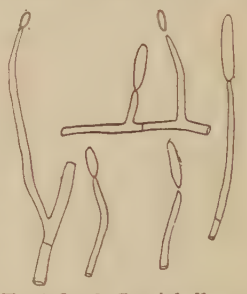
When gathered the pustules of *C. trichellum* are found on leaf spots or dead areas of the leaf, and the fungus is at first probably saprophytic. It can apparently act as a weak parasite, since if leaves having only a few fructifications are left in a damp chamber the area affected will spread gradually over the remaining green portion of the leaf, and finally acervuli will arise all over, even spreading down the petiole. It is capable of behaving as a wound parasite, as will be shown later.

The acervuli when freshly gathered consist of flat, round or oblong layers; when kept in a damp atmosphere for ten days or more they form a raised stromatic disc with the hymenium on the surface, while if kept for longer, large sterile sclerotia are formed on the petioles, comparable with those found in *C. Dematium*, etc., and regarded as a winter resting stage. The acervuli are initiated under the cuticle of the epidermis of the leaf, but soon become erumpent, are black to the naked eye, but when freshly sporing in a damp chamber a globule of cream coloured fluid appears on the surface. This is found to consist of masses of colourless spores. The setae are straight or slightly bent, rigid, brittle, with acute apex and subulate base, septate, thick-walled, brown-black, paling at the apex and paler when young, up to 270μ long and 8–10μ broad at the base. The length and colour of these organs are, however, very variable; short and pale when young, they elongate and become much darker as they mature. The conidiophores are cylindrical, hyaline. The conidia are fusiform, straight or slightly curved, with central nucleus seen in stained preparations, and with one or several oil drops; 15–28 × 3–5μ, average 23–4μ (Text-fig. 5, 5).

The Ivy fungus was obtained in culture in November 1924, on Dox's agar. A pure white cob-webby growth occurred all over the slant and about the fifteenth day the initial stages of

acervuli were observed on the edges of the culture only. These were never found in quantity and never all over the culture as in other forms. After about twenty-one days a very pale flesh-pink colour was observed throughout the cultures.

Further isolations on the same medium were made in 1926 and 1927 from Ivy leaves found in Kew Gardens. The resulting cultures all agreed with each other, but differed in certain respects from the original isolation obtained in 1924. The first growth was, as previously, white; but after seven to nine days a slight darkening of the aerial hyphae became evident, and black sclerotia began to be formed irregularly over the slant. The ultimate appearance of the culture showed a white or pale smoke coloured mycelial ground, with large or small, very irregularly shaped, black sclerotia scattered all over (Pl. IX, fig. 3 *D*). The general aspect of the culture was rather like that of *Botrytis cinerea*. The sclerotia when examined microscopically were found to possess short black setae. Sometimes pustules of spores were developed, and appeared as slimy cream coloured drops on the surface of the sclerotia. In young cultures (five to six days old) on gelatine plates spores were produced directly on the mycelium (Text-fig. 6) in the manner described by Cavadas (34) for *V. varians* (*C. atramentarium*). In every culture a greenish (between Olive Yellow and Light Yellowish Olive) pigment was developed to a greater or less extent. This colour faded with age, and in one isolation a flesh-pink coloration became evident, recalling the 1924 cultures of this species.



Text-fig. 6. *C. trichellum*: spores formed directly on mycelium; from culture on Dox's agar. × 445 approx.

To check the identity of the cultures, Ivy leaves, superficially sterilised with a weak formalin solution and afterwards washed with sterile water, were wounded with a sterile scalpel and inoculated with mycelium from one of the cultures. Some leaves were inoculated, but not wounded. They were then placed in sterilised Petri dishes containing sterilised filter papers moistened with sterile water. In all wounded leaves infection occurred, and a circular spot, varying in colour from Saccardo's Umber to a deeper brown (Fuscous) was formed. Acervuli and spores typical of *C. trichellum* were produced in large numbers in concentric rings on the discoloured areas. The negative results obtained where the leaf was not wounded showed that the fungus was a wound parasite only. Control leaves, wounded but not inoculated, showed no evidence of infection (Pl. IX, fig. 1).

Hanging drop cultures in water and nutrient gelatine were made in order to ascertain the mode of germination. The conidia germinated rapidly, well-developed germ tubes being visible within eighteen hours. Sometimes the formation of a median septum occurred before germination. First one germ tube was produced at or near the end of each spore, and later two or more arose from almost any point on the spore (Text-fig. 4). Hyphal fusions occurred very commonly either between different individuals, or between different branches of the same individual. Germination occurred much more quickly, and resulted in larger and healthier individuals in the gelatine drops than in the water.

In the hanging drop water cultures, an abundant development of thick-walled, smoke-coloured, variously-shaped appressoria or chlamydospores occurred after four days. These were terminal, appeared to consist of one, two or more cells, and contained one to several oil drops. They measured 10–20 × 8–15μ (Text-fig. 7) and were capable of germination producing one or two delicate, short, hyaline hyphae which gave rise terminally to similar appressoria. The view expressed by Edgerton (35) that the formation of appressoria is a consequence of lack of nutrition is confirmed by these experiments, since these structures were absent in the gelatine drops, and were formed most readily towards the outside of the water drops.

Text-fig. 7. *C. trichellum*: appressoria formed in hanging drop water cultures. ×445 approx.

The formation of dark coloured appressoria or secondary spores has generally been considered to be a characteristic feature of anthracnose fungi whose perfect stages belong to the genus *Glomerella* (*loc. cit.*). The presence of such in *C. trichella* is interesting, since it suggests that this fungus and the group to which it belongs, may also prove to belong to the *Glomerella* association.

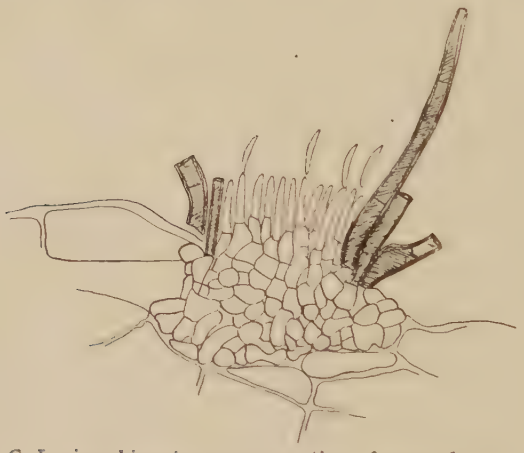
Two other species of *Colletotrichum* recorded on Ivy leaves must be considered: *C. gloeosporioides* var. *Hederae* Passer. (36) (= *C. Hederae* Passer. of Diedicke (8)), and *C. hedericola* Laub. (37). According to Passerini (36) the former differs from the type in its twisted setae, and in the fusiform, straight or curved spores, 18–20 × 5–6μ. *C. hedericola* Laub. is differentiated from *C. gloeosporioides* var. *Hederae* by its straight septate bristles and more slender spores, 17–25 × 3–5μ (37). Through the courtesy of Dr Ulbrich of the Botanisches Museum in Berlin, a portion of

the type of *C. hedericola* Laub. was sent on loan to the writer. Unfortunately this material was very scanty, but so far as could be determined, the differences between this species and *C. trichellum* seem too slight to admit of separate specific rank. The size of the acervulus of *C. hedericola* is slightly smaller, and the setae are shorter than in *C. trichellum*, but the spore characters are very similar.

Keissler (38, 39) has expressed the view that *C. gloeosporioides* var. *Hederae* and *C. hedericola* are probably identical. I have not been able to examine authentic material of the former, but it seems unlikely that the two are distinct. Finally Sydow has stated (40) that *C. gloeosporioides* var. *Hederae* and *V. trichella* forma *Hederae* are probably identical, representing forms of the same species. The probability is therefore, that only one species of *Colletotrichum* occurs on Ivy, and this, on priority grounds, must be known as *C. trichellum* (Fr.).

6. ***Colletotrichum Lysimachiae*** n. sp.

A species of *Colletotrichum* on *Lysimachia nemorum* was found for the first time, at Enniskerry, Co. Wicklow, in September



Text-fig. 8. *C. Lysimachiae*: transverse section of acervulus. ×445 approx.

1925. A year later it was found again on the same host near Hereford, and at Virginia Water. It is evidently of fairly common occurrence on the yellow Pimpernel. The characteristic setose pustules were first observed on dead lower leaves and on brown spots on upper living ones, but on keeping specimens in a damp atmosphere, all leaves, as well as stems and fruits, became infected and showed acervuli. The species is weakly parasitic. The sporing acervulus is small and not much raised

above the surface of the substratum (Text-fig. 8). Larger sterile winter sclerotia are developed later on the stems, forming the resting stage. Setae and spores (Text-fig. 5, 6) are analogous to those of other species.

Isolations on Dox's agar resulted in a brownish gray (Pale Smoke Gray to Smoke Gray) felty growth, with sometimes small black sclerotia irregularly placed over the surface. The aspect of the cultures was not very different from that of *C. Liliacearum*, but rather more brownish and felty (Pl. IX, fig. 3*B*). Inoculation of *Lysimachia nemorum* with mycelium from these cultures has, however, failed to produce positive results. The identity of the fungus in culture is therefore uncertain, especially as no spores have been produced on the artificial medium.

The only other British species obtained by the writer comparable to this in general characters, and growing on leaves of a dicotyledonous host plant is *C. trichellum* on Ivy. The unrelated host plants, the more delicate acervuli, slightly larger spores, and the possible difference in the aspect of the former fungus in culture all tend to point to specific difference.

Colletotrichum Lysimachiae n.sp.

Acervuli amphigeni gregarii, subcuticulares dein erumpentes, rotundi vel oblongi, minuti usque ad 130μ diam. (seniora sclerotia sterilia usque ad 250μ diam.), atri, setulis obsiti. *Setulae* rigidae, rectae vel arcuatae, tunicis crassis, septatae, basi incrassatae, atro-brunneae, apice pallentes, juniores pallentiores, usque ad 270 × 7–8μ. *Conidiophori* cylindrici, hyalini, intra setulas dense fasciculi. *Conidia* continua, hyalina, fusiformes, leviter curvula, nucleo centrale, 20–28 × 4–5μ.

Hab. in foliis, caulibus et fructibus *Lysimachiae nemorum*, Enniskerry, Co. Wicklow, 20. IX. 25; Dinmore Hill, Hereford, 29. IX. 26; Virginia Water, 23. X. 26.

7. *Colletotrichum Wahlenbergiae* n.sp.

A *Colletotrichum* sp. was found on the dead parts of leaves of a diseased plant of *Wahlenbergia* sent to Kew in October 1926. The fungus was in the sclerotial stage, but a fair number of spores were seen. The dark sclerotia agree with those generally found in the genus, being subcuticular in origin and becoming erumpent through the agency of the developing setae. The latter are rigid, and diverge somewhat from their point of origin on the sclerotium. They are subulate at the base, taper upwards towards the apex, and are irregular in outline. Their colour varies from dark brown at the base to almost hyaline at the tip. Septation occurs throughout their length which may be up to about 125μ. The characters so far described do not differ sufficiently to merit the description of a new species. It is on

the nature of the spores that specific difference is based. These are continuous, hyaline, straight cylindrical (cigar shaped), with blunt ends, and many oil drops, 16–22 × 3–4·5 μ (Text-fig. 5, 7). Such spores are found in *C. atramentarium* alone of all the British species noted here. The unrelated host plants, and the difference in position on the latter, seem to indicate a specific difference.

Owing to the scarcity of spores it was impossible to procure pure cultures.

Colletotrichum Wahlenbergiae n.sp.

Sclerotia amphigena, sparsa vel gregaria, interdum confluentia, subcuticularia dein erumpentia, pulvinata, rotunda vel oblonga, atra, setulis obsita. *Setulae* rigidae, divergentes, linea exteriore parum irregulares, septatae, subulatae, versus apicem attenuatae, fuscae, apice pallentes, usque ad 125 μ longae. *Conidia* continua, hyalina, cylindrica, recta, apicibus obtusa, guttulata, 16–22 × 3–4·5 μ.

Hab. in foliis mortuis *Wahlenbergiae* sp., Upper Caterham, Surrey, October 1926.

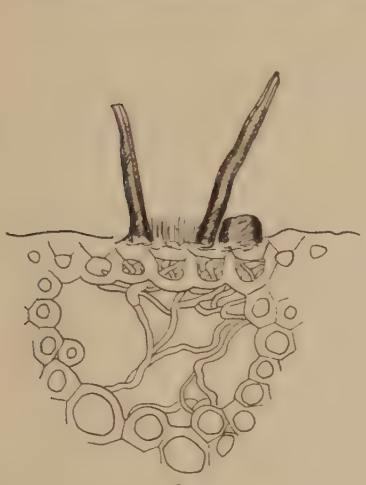
8. ***Colletotrichum Holci*** (Syd.) Grove in *Journ. Bot.* LVI (1918), 341.

Vermicularia Holci Syd. in *Hedw.* XXXVIII (1899), 137.

Material of *C. Holci* was obtained on the dead leaves and culms of *Holcus lanatus* at Holme Lacy, near Hereford, and at Epping Forest, in October 1926. On the pale coloured dry stems and leaves the acervuli and sclerotia of the fungus show up well as minute narrow black spots, oblong, arranged more or less in a parallel series, and the individual pustules often confluent end to end, so as to form black stripes sometimes ¾ mm. in length, and about 75–100 μ in breadth. A surface or a transverse section shows that each sporing acervulus is situated above a cavity formed by the degeneration, for some reason, of the delicate assimilatory tissue, is flat, and possesses at this stage, little stromatic tissue. The setae are septate, have a subulate base, are rather shorter than in other species, never having been found more than 130 μ long even though kept for weeks in a damp atmosphere, and in colour are paler brown with hyaline tips. Grove remarks on the thinness of the proliferous stratum and the paleness of all its parts. The spores are of the normal shape, curved mostly and 20–30 × 4–5·5 μ in size (Text-fig. 5, 8). After fruiting, the fungus mycelium penetrates the epidermis and ramifies in the cavity immediately below. Finally this cavity is filled with fungal hyphae and a brown sclerotium consisting of thick-walled irregular cells is formed (Text-figs. 9–11). The epidermal cells are also filled with dark stromatic tissue, and the sclerotium is very evidently black from the out-

side. The setae are deciduous, leaving a smooth, shiny, flat, internal sclerotium.

This is the only species of grass which I have found with any form of *Colletotrichum* upon it. There are however seventeen species and one variety of so-called *Vermicularia* recorded on different grasses in other countries. It is probable that a search



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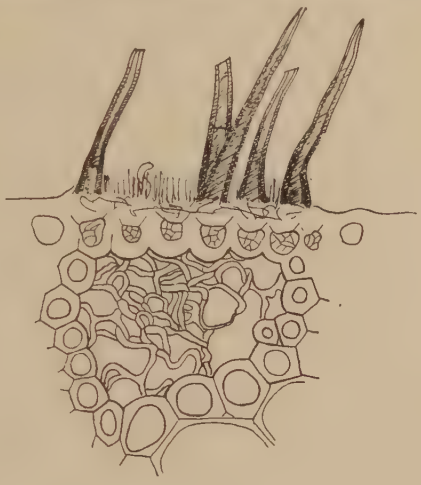

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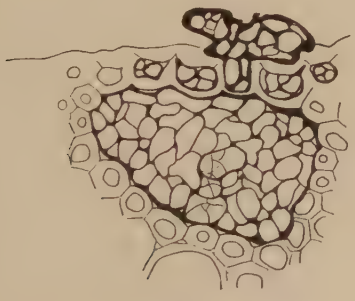

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Text-figs. 9–11. *C. Holci*: transverse sections showing development of internal sclerotium. 9, hyphae penetrating cavity; 10, packing of hyphae in cavity; 11, sterile sclerotium entirely filling cavity. All ×445 approx.

on various grass species will reveal other forms in Britain, and that the seventeen species on Gramineae will resolve themselves into, at the most, six or eight. A morphological comparison of authentic herbarium material of *C. Holci* with *V. graminicola*, and *V. Lolii*, indicate similarity in structure of these three species and the possibility of their being the same.

9. ***Colletotrichum circinans*** (Berk.) Voglino in *Ann. R. Accad. Agr. Torino*, XLIX (1907).
Vermicularia circinans Berk. in *Gard. Chron.* XXXVIII (1851), 595.

This species, the cause of the disease known as Onion Smudge, has been described in full by Walker (13). The general structure agrees with that of all those dealt with in this paper. The spores are fusiform curved and vary in size: "14–30 × 3–6μ, usually 18–28 × 3–4μ" (Walker) (Text-fig. 5, 9).

A culture of this species was kindly sent by Dr J. C. Walker and agreed with other cultures of different species in its grayish colour, and general characters.

SPECIES WHICH HAVE NOT BEEN SEEN BY THE WRITER, OR WHICH ARE INSUFFICIENTLY KNOWN.

10. ***Colletotrichum petiolicola*** (Brun.) Grove in *Journ. Bot.* LVI (1918), 341.
Vermicularia petiolicola Brun. *Sphaerops. Char.* p. 36, 1889.

No material of this species which was recorded on the fallen petioles of *Acer pseudoplatanus* in Cheshire by Grove has been available, although a strict search on these and other petioles was made throughout the autumn and early winter of 1926 in Kew Gardens and elsewhere near London.

11. ***Vermicularia epixyla*** Fr. *Summa Veg. Scand.* p. 420, 1849.

This species was recorded by Massee (41), growing on dead branches in Kew Gardens. No material of this or of any other gathering is represented in Herb. Kew., so that the structure could not be determined. It is probable, however, that this species will, like the others, prove to be a *Colletotrichum*.

12. ***Colletotrichum chaetostromum*** (B. & Br.) Duke nov. comb.
Excipula chaetostroma B. & Br. in *Ann. Nat. Hist.* 2 ser. V (1850), 456.

This species was recorded on "ash keys, Leigh Wood, Bristol" in 1847 by Berkeley and Broome, and given the generic name *Excipula*. What is evidently the type specimen is present in the Kew Herbarium, and is labelled in Berkeley's handwriting "*Vermicularia chaetostroma* B. & Br." Saccardo (11) removed it to the genus *Amerosporium*, and on the herbarium sheet Grove has written "*Amerosporium chaetostroma* Sacc." Examination of the specimen showed that it is a typical *Colletotrichum* and not an Excipulaceous fungus. No disc characteristic of the latter family is present, but an oval, pulvinate, erumpent, setose sclerotium, with free fertile layer on the surface. The setae are

typical of the genus. The spores are fusiform, slightly curved, 15–23 × 2·5–3·5 μ (Text-fig. 5, 10).

There is unfortunately some doubt as to the host of this species. Berkeley and Broome state that it was found on Ash keys. The fragment of material in the Kew Herbarium is so small that it would be impossible to state with certainty what it is. Hence the species remains one imperfectly known.

13. ***Colletotrichum uncinatum*** (B. & C.) Duke nov. comb.
Vermicularia uncinata B. & C. in *Grevillea*, III (1874), 6.

This is an American species described on the stems of *Desmodium nudiflorum* but is included here since Massee (41) records it on twigs of this plant in Kew Gardens. In the Kew Herbarium there is a specimen of Berkeley's, No. 4691, but Massee's specimen is not preserved. The spores are described as being large, hamate, attenuated towards the base, with a distinct membrane, 60 μ long, and drawings of such structures are given with Berkeley's specimen; they are not spores at all, but hairs of the host plant. The specimen consists of a subcuticular, black, round-oval stroma which later becomes erumpent. It is about 175 μ in diameter, up to $\frac{1}{2}$ mm. long, and beset with setae which are as in other species, rigid, subulate and 10–12 μ in diameter at the base, thick-walled, septate, and very dark brown, only slightly paler at the mature tips. The stroma is composed of thick-walled irregular cells towards the base and middle, with a layer of palisade-like conidiophores on the surface, lighter in colour than the lower cells and thin-walled. The sclerotia are quite sterile, so that at present the species is imperfectly known.

14. Examination of the British species of *Vermicularia* in the herbarium of the British Museum (Natural History) revealed one further record: *V. relicina* Fr. The specimen is from Bloxham's herbarium, is labelled "*Sphaeria relicina* on *Nardus stricta*," and bears the date October 11th, 1837. As the fungus is in the sclerotial stage, and no spores could be found, little can be said here. The structure of the sclerotia, and their internal position in cavities formed by the degeneration of the soft assimilatory tissue, strongly recall *C. Holci*.

15. Another species placed on record as a British fungus is *Vermicularia corvina* Karst. Massee (43) reports that it was found "on chips, Queen's Cottage" in 1906, and states that it was "new to Britain." The Kew specimen has been examined and found to be a pycnidial fungus with matted hairs on the outside of the pycnidium, and with straight cylindrical spores. The fungus is in fact a species of *Pyrenochaeta* resembling *P. Robineae*. Hence the record of *V. corvina* for Britain must be deleted.

SUMMARY.

An investigation into the history of the genera *Vermicularia* Fr. and *Colletotrichum* Cda., combined with an examination of the structure of authentic specimens, has led to the conclusion that there is no essential difference between these genera. This duplication of one genus arose through the wrong conception of its structure held by Fries. Evidence of this was afforded by examination of Fries's own specimens. The possibility is moreover pointed out that both genera were founded on one species.

It is proposed, for reasons of convenience, to conserve the later name *Colletotrichum* Cda. for the combined genus. *Colletotrichum* Cda. is characterised by an innate acervulus which afterwards becomes erumpent, dark brown setae, and elongated, oblong or fusiform, curved or straight conidia. Species with few, or at times, no setae are not typical and are regarded as transition species to *Gloeosporium*. The actual relation of these two genera is not further considered.

Comparison with *Volutella* Fr. indicates that this is distinct from *Colletotrichum* Cda. and characterised by its superficial origin, hyaline setae and smallish oval spores.

Critical notes, and in some cases, cultural characters, of the following species of *Colletotrichum* (*Vermicularia*) based on fresh material are recorded: *C. Dematium*, *C. Eryngii*, *C. Liliacearum*, *C. trichellum* and *C. Holci*; *C. Lysimachiae* and *C. Wahlenbergiae* are described as new species.

It is with pleasure that I express my gratitude to Dr E. J. Butler of the Imperial Bureau of Mycology for suggesting this problem; to Miss E. M. Wakefield and to Mr A. D. Cotton of the Herbarium, Royal Botanic Gardens, Kew, for their very helpful criticism and advice; and to Mr G. Atkinson, Kew, for taking the photographs.

REFERENCES.

(1) TODE, H. J. Fungi Mecklenburgenses Selecti, I. 1790.
(2) PERSOON, D. C. H. Synopsis Fungorum, p. 110. 1801.
(3) NEES VON ESENBECK, C. G. Das System der Pilze und Schwämme, p. 311. 1817.
(4) Actes du IIIme Congrès International de Botanique, Bruxelles, I (1910), 61.
(5) FRIES, E. Systema Mycologicum. 1821–32.
(6) —— Systema Orbis Vegetabilis. 1825.
(7) —— Summa Vegetabilium Scandinaviae, II. 1849.
(8) DIEDICKE, H. Fungi Imperfecti in Krypt. Flor. Mark Brandenburg, IX (1912–15).
(9) FRIES, E. Elenchus Fungorum, II, 107. 1828.
(10) FUCKEL, L. Symbolae Mycologicae. 1869–70.
(11) SACCARDO, P. A. Sylloge Fungorum, III. 1884.
(12) RABENHORST. Krypt. Flora Deutsch. I, 6–9. 1901–10.
(13) WALKER, J. C. Onion Smudge. Journ. Agric. Res. XX (1921), 685–721.

(14) Voglino, P. I Funghi parassiti delle piante osservati nella provincia di Torino e regioni vicine nel 1906. Ann. R. Accad. Agr. Torino, xlix (1907), 175–202.
(15) Desmazières, J. B. H. J. Plantes Cryptogames de France. Sér. 1. 1825–51.
(16) Potebnia, A. Beiträge zur Micromycetenflora Mittel-Russlands. Ann. Myc. viii (1910), 42–93.
(17) Höhnel, F. von. Zur Systematik der Sphaeropsideen und Melanconieen. Ann. Myc. ix (1911), 258–265.
(18) —— System der Fungi Imperfecti Fuckel, in Falck, R., Myk. Unters. u. Berichte, i (1923), 301–369.
(19) Archer, W. A. Morphologic characters of some Sphaeropsidaceae in culture with reference to classification. Ann. Myc. xxiv (1926), 69.
(20) Briosi, G. and Cavara, F. I Funghi parassiti delle piante coltivate od utile, No. 340.
(21) Grove, W. B. New or Noteworthy Fungi, vi. Journ. Bot. lvi (1918), 341.
(22) Dickson, B. T. *Colletotrichum* v. *Vermicularia*. Mycologia, xvii (1925), 213–217.
(23) Höhnel, F. von. Fragmente zur Mykologie, p. 404. Sitzungsber. d. Kaiserl. Akad. d. Wissenschaft. in Wien, mathem.-naturw. Klasse, cxviii (1909), 1236.
(24) Pethybridge, G. H. Some Saprophytic Fungi of Potatoes. Trans. Brit. Mycol. Soc. vi (1918), 104–120.
(25) Krüger, F. Beiträge zur Kenntnis einiger Gloeosporien. Arb. kais. biol. Anst. f. Land- u. Forstw. ix (1913), 303.
(26) Corda, A. C. J. Pilze, in Sturm, J., Deutschlands Flora, iii, 3, 41–42, Pl. 21. 1837.
(27) Saccardo, P. A. Fungi Veneti, Series xii. Michelia ii (1881), 271.
(28) Dickson, B. T. Saltation in the Organism causing "Black Dot" disease of Potato in Canada. Proc. and Trans. R. Soc. Canada, ser. 3, xvii (1923), sect. 5, 123–7.
(29) Stoneman, Bertha. A Comparative Study of the Development of some Anthracnoses. Bot. Gaz. xxvi (1898), 69–120.
(30) Ducomet, V. Une nouvelle Maladie de la Pomme de Terre; la "Dartrose." Ann. École d'Agric. Rennes, ii (1908), 24–47.
(31) Killian, C. Caractères morphologiques et culturaux du *Vermicularia Eryngii*. Bull. Soc. Myc. Fr. xlii (1926), 51–61.
(32) Bewley, W. F. and Shearn, J. A Root Disease of the Tomato caused by *Colletotrichum tabificum* (Hallier pro parte) Pethybridge. Ann. of Appl. Biol. xi (1924), 244–251.
(33) Dickson, B. T. The "Black Dot" Disease of Potato. Phytopath. xvi (1926), 23–40.
(34) Cavadas, D. S. Notes sur la "Dartrose" de la pomme de terre et ses conséquences. Rev. Path. Vég. et Ent. Agric. x (1923), 4–5.
(35) Edgerton, C. W. The Physiology and Development of some Anthracnoses. Bot. Gaz. xlv (1908), 384.
(36) Passerini, G. Diagnosi di Funghi nuovi. Nota iv. Memor. R. Accad. Lincei, ser. 4, vi (1890), 469.
(37) Laubert, R. *Colletotrichum hedericola* nov. spec., als Schädiger von Efeu. Arb. kais. biol. Anst. f. Land- u. Forstw. v (1907), 503–4.
(38) Keissler, K. Fungi, in Zahlbruckner, A. Schedae ad "Kryptogamas exsiccatas." Ann. d. k. k. naturh. Hofmus. xxiii, 1 (1909), 218.
(39) —— Zur Kenntnis der Pilzflora Krains. Beih. Bot. Centralbl. xxix, 2 (1912), 428.
(40) Sydow, H. In Diedicke, H. Die Blattfleckenkrankheit des Efeus. Centralbl. f. Bakt. xix (1907), 172.
(41) Massee, G. The Wild Fauna and Flora of the Royal Botanic Gardens, Kew. Kew Bull. Add. Ser. v (1906), 173.
(42) Berkeley, M. J. and Broome, C. E. Notices of British Fungi. Ann. Nat. Hist. ser. 2, v (1850), 456.
(43) Massee, G. Additions to the Wild Fauna and Flora of the Royal Botanic Gardens, Kew: iv. Kew Bull. (1907), 241.

EXPLANATION OF PLATE IX.

Fig. 1. Ivy leaves inoculated with culture of *C. trichellum*: *A*, wounded and inoculated in three places; *B*, wounded and inoculated in two places, inoculated but not wounded at *X*; *C*, control, wounded but not inoculated. ⅔ nat. size.

Fig. 2. Photomicrograph of transverse section of *V. Dematium*, Fries's material, showing sclerotium bearing spores on surface, and setae. × 250 approx.

Fig. 3. Cultures: *A*, *C. Eryngii*; *B*, *C. Lysimachiae*; *C*, *C. Liliacearum*; *D*, *C. trichellum*. ⅔ nat. size.

CERATOSTOMELLA PARADOXA, THE PERFECT STAGE OF THIELAVIOPSIS PARADOXA (DE SEYNES) VON HÖHNEL.

By H. A. Dade, A.R.C.S., Mycologist, Dept. of Agriculture, Gold Coast Colony.

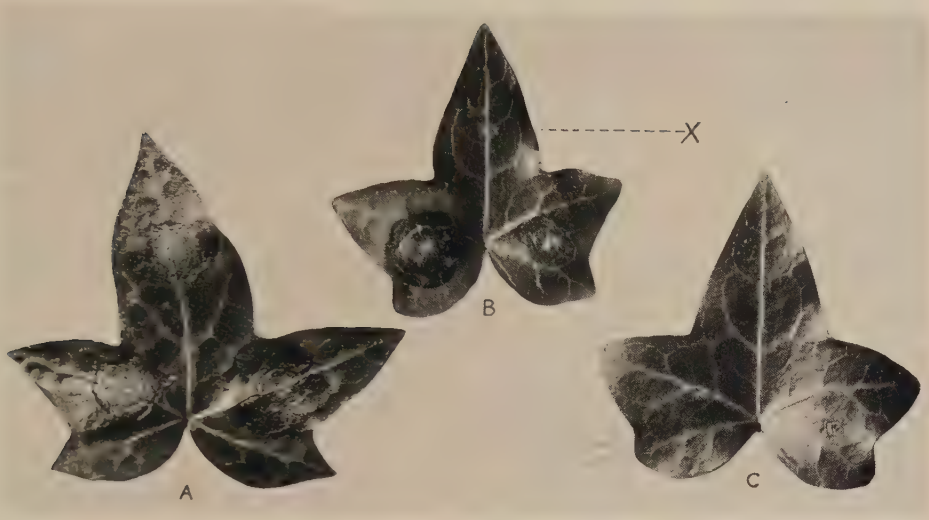
(With Plates X–XII.)

Thielaviopsis paradoxa, first described as *Sporochisma paradoxum* by de Seynes, is well known to mycologists in the tropics. The excellent and detailed description by Petch (1) renders any further general account superfluous, and the conidial forms will be only briefly referred to. In only a few unimportant details is Petch's account capable of qualification or amplification. Petch also conveniently summarises the work of earlier investigators, and provides a full bibliography.

Massee (2), as the result of cultural work at Kew, considered that *T. paradoxa* and a species of *Melanconium* were stages in the life-history of *Trichosphaeria Sacchari*.

In this opinion he was supported by a few other workers, but Petch points out that the evidence for the supposed identity of the three fungi is vague, and that the experimental work performed by Massee was not satisfactory; as the result of his own work he concludes that the other forms found in Massee's cultures were contaminations, and that at least the strains in his possession produced only micro- and macroconidia and *Stysanus* (or coremial) forms; he was undoubtedly correct in assuming that *Melanconium* and *Trichosphaeria* were not related in any way to *Thielaviopsis*.

His conclusions were based on carefully isolated single-spore cultures, thus excluding the possibility of contamination. It is now evident, however, that the method of monosporous cultures used was that most certain to conceal a genuine peri-



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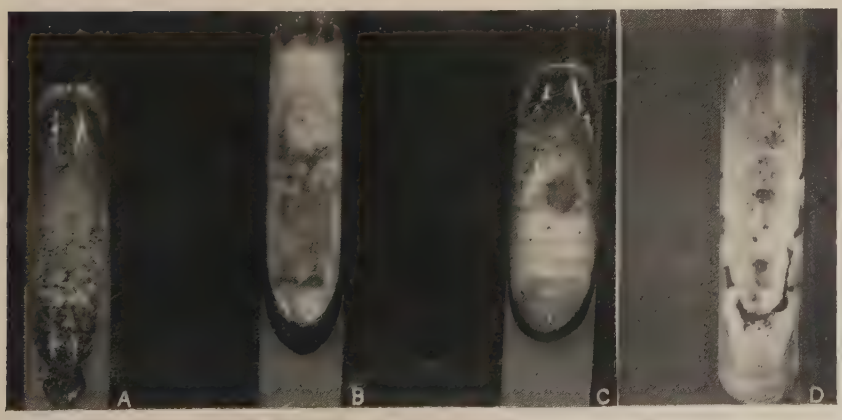

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thecial stage, or as it might have been then considered, a pycnidial form.

Patterson and Veihmeyer (3) briefly record a "pycnidial" form which appeared irregularly in their cultures, but do not describe it nor assign to it a generic status.

Elliot (4, 5) has now shown that *Sphaeronema fimbriatum*, the conidial stages of which closely resemble those of *Thielaviopsis*, is really a *Ceratostomella*, and Sartoris (6) has recently shown that *Sphaeronema adiposum* (Butl.), is also a *Ceratostomella*.

Thielaviopsis paradoxa is widely known in the tropics as a pathogen of sugar cane, pineapples, and coconut palms. In the Gold Coast this fungus was first recorded by the writer in 1924 as causing a stem rot of oil palm (*Elaeis guineensis*). It has subsequently been recorded here by Bunting (7) as a parasite of pineapple, coconut palms and oil palms. It was again found in 1926 (8) as a saprophyte on the mucilaginous tissue of cacao husks in the heaps left by farmers after harvesting.

In the first and last records, but not in the others, a Sphaeronemoid spore-form was found in association with *T. paradoxa*. Early cultures from the stem rot of oil palm produced a few Sphaeronemoid bodies but carefully isolated cultures from micro- and macroconidia formed only micro- and macroconidia and *Stysanus* forms, thus supporting Petch's views, and it was concluded that the Sphaeronemoid form was a distinct fungus.

The large numbers of Sphaeronemoid bodies which were frequently associated with *T. paradoxa* from cacao husks again aroused suspicion, and led to more careful study. The Sphaeronemoid form is now known to be the perithecial stage.

Material collected from cacao husks at Anyinam in 1927 was used.

Pure cultures on corn meal agar were obtained by various methods: (*a*) By plating from suspensions of micro- and macroconidia. (*b*) By removing chains of aerial conidia with a needle, with the aid of a Leitz binocular magnifier; the fungus grows rapidly on suitable media and chains of aerial microconidia are free from contamination and easily picked out. (*c*) By removing clean masses of ascospores from the beaks of perithecia. The necks of perithecia are often invested with climbing hyphae producing conidia (Pl. X, fig. 1), which are frequently found adhering to the ascospore mass. Clean perithecia are easily found with the Leitz magnifier. (*d*) Finally by cultures derived from single ascospores. This presented some difficulty, for the ascospores adhere in masses in a fatty matrix, and cannot be separated in a suspension. Masses were therefore removed from the perithecia and smeared out on sterile slides with the platinum needle—this having the effect of separating the spores

before adding water. Drops of sterile water were then added, and the ascospores rubbed up in them. These suspensions were then diluted, and loops from them transferred to squared agar plates. After about fifteen hours young growths from single spores were picked out under the microscope and transferred to slants.

The Perithecial Stage.

The perithecia, which are illustrated in Pl. X, are of typical *Sphaeronema* form—flask-shaped, with a spherical bulb and a long thin beak. The bulb is hyaline or only faintly coloured, is composed of three or four layers of cells and is from 200 to 350 μ in diameter, usually about 250 μ. It is immersed or almost completely immersed in the substratum; it has been studied only on soft substrata, and if ever found on hard material it may be superficial, but the conditions necessary for its formation would probably not occur on a hard (*e.g.* woody) substratum.

The beak is black and shining, 800 to 1200 μ long and 30 to 40 μ in diameter, composed of four or five layers of parallel hyphae, fimbriate and hyaline at the apex, the fimbriate part being about 100 μ long (Pl. XI, fig. 20).

On the upper part of the bulb, surrounding the insertion of the beak, very characteristic appendages are borne. They arise from cortical hyphae as dark brown terminal cells of complex form which appears to be due to irregular, very condensed ditrichotomous branching. Their appearance is difficult to describe, though it may perhaps be termed stellate-coralloid (Pl. X, fig. 2 and Pl. XI, fig. 21).

Perithecia vary in the number of appendages produced; only two or three may appear, especially in perithecia grown on artificial media, but sometimes, particularly on natural substrata, the whole of the upper hemisphere of the bulb may be completely covered with appendages.

Perithecia have their origin in knots of hyphae, but specialised antheridia and archegonia have not been distinguished. The core of the hyphal knot subsequently breaks down, forming the cavity of the bulb, which is lined with ascogenous hyphae and filled with large thin-walled sterile cells. A detailed cytological study has not been made but the development of the perithecium is apparently similar to that of *Ceratostomella fimbriata* as described by Elliot (5).

The outer layers of the perithecial knot now begin to differentiate into more thickly walled cells forming the wall of the bulb. With the exhaustion of the large thin-walled storage cells the ascogenous hyphae, which have grown across the cavity in all directions, form a definite stratum on the inner layer of the perithecial wall, and give rise to asci.

Stages in the development of the perithecium and ascus are illustrated in Pl. X, figs. 4–7 and Pl. XI, figs. 16–19.

The ascus is extremely fugitive and difficult to demonstrate. Asci may very occasionally be found by crushing living perithecia under a cover slip, but only one attempt in hundreds is successful.

Perithecia are full grown four to five days after sowing a mixed culture.

Material for paraffin sections is best fixed by Fleming's weaker solution, and transference from the complete solution to a similar solution minus the osmic acid after one hour, renders bleaching unnecessary. Both Heidenhain's and Fleming's stains were used.

The ascospores are at first apparently irregularly biseriate (Pl. XI, fig. 18), but later, if the ascus persists long enough, as it occasionally does, the arrangement of the ascospores is indefinite (Pl. XI, fig. 19). Sometimes, clumps of eight ascospores, in biseriate formation (Pl. XI, fig. 17) are seen when asci are crushed, adhering together by the fatty matter which is formed in the ascus.

Empty asci in which ascospores have not been formed are occasionally seen (Pl. XI, fig. 16).

Elliot (5) states that the ascospores of *C. fimbriata* may continue their development after the dissolution of the ascus and apparently this may also occur in the fungus now under discussion, for full-sized ascospores have been found in asci only when the asci have persisted for rather longer than is usual.

Asci are clavate and stipitate, and their size depends upon the period of persistence, if they are to be considered fully grown at the time of dissolution.

Ascospores are elliptical, frequently more convex on one side (the flatter side is never concave) $7–10\mu \times 2{\cdot}5–4\mu$. After the dissolution of the asci they are found free in the bulb and neck, and are finally extruded at the tip of the beak. Before extrusion of spores the hyphae of the hyaline fimbriate tip are closely adpressed, but after extrusion they spread out and support the spore mass which is globular, shining, translucent and pearly in colour, the spores being held together by the fatty substance produced in the asci.

With age the mass becomes yellow and less regularly spherical. The masses, especially when freshly extruded, are very sticky and have been observed adhering to the bodies of insects.

Germination of Ascospores.

Germination of ascospores has been studied principally in hanging drops composed of juice from the mucilaginous tissue

surrounding cacao "beans." Sometimes "beans" were removed with sterile knives and forceps from ripe pods, and rubbed on flamed cover slips; a loop of a suspension of ascospores in sterile water was then placed on each slip. Afterwards a suitable medium was made in bulk by removing mucilaginous tissue from beans, gently heating it in water, filtering, tubing and sterilising in a steam steriliser.

Germination does not take place in water, but proceeds rapidly in the medium described above. The spore swells gently and eventually becomes spherical. The sequence of events in germination varies considerably, and is apparently dependent on such conditions as the concentration of the medium and the amount of competition from neighbouring germ-vegetations. Actually the variation consists in the extent to which vegetative mycelium is formed. A considerable mat may be formed, secondary and tertiary germ tubes arising from the spore, which subsequently gives rise to lateral microconidiophores and then macroconidiophores (Pl. XII). Or a very short microconidiophore may be developed directly from the germinating ascospore, and a chain of microconidia ejected, this completing the activity of the ascospore vegetation (Pl. XII, fig. 27). Sometimes anastomoses between neighbouring germinating ascospores are very common (Pl. XI, fig. 15).

Notes on the Conidial Stages.

Petch (1) states that production of microconidia invariably precedes that of macroconidia. While this is certainly most usual it is not necessarily always so. Figs. 11–13 in Pl. XI show germinations from microconidia in which macroconidia have been directly produced, sometimes from normal macroconidiophores, sometimes from a macroconidiophore which has been formed on the terminal segment of what was obviously a primary microconidiophore.

The latter phenomenon is no doubt similar to that which occurs commonly, both in artificial cultures and in nature in microconidiophores, when, after discharge of the conidia is completed, the terminal segment of the conidiophore grows on to form a second active conidiophore. The process, which is illustrated in Pl. XII, figs. 24–26, may be repeated again.

In Pl. XII, fig. 25 two successive conidiophores, marked at their tips *A* and *B*, have discharged two sets of conidia, most of one set of which has formed epispores and the other germinated in most cases. A further extension of growth has begun (*C*).

It seems clear that these variations from the normal are due to a condensation of ordinary growth—the suppression of vegetative mycelium and more rarely, of the microconidial form.

Petch states that a membrane is formed round the macroconidia before extrusion. This is at least not invariably so, but the fungus is rather plastic, and such variations from the normal are probably of no importance.

This plasticity extends to what Petch describes as the *Stysanus* form. In its highest degree of development this form consists of a number of very long microconidiophores closely assembled to form a compact upright cylindrical column. The conidiophores are individually olivaceous in colour, and black in mass. This body is of considerable size, and with its terminal mass of microconidia very closely resembles the beak of a perithecium, for which it may at first be mistaken.

The initial stage of formation of the Stysanoid or coremial form is illustrated in Pl. XI, fig. 10. A branched vegetative hypha thickens, the septa are formed so as to produce short cells, from each of which rises a microconidiophore. The conidiophores arise vertically and closely adherent.

Other degrees of development are common in culture. Neither the compactness nor the deep colour of the highest type may be attained. The long coloured conidiophores may be formed singly (Pl. XI, fig. 8) or a few conidiophores may be formed from the hyphal knot, and may lie on the surface of the medium. When larger numbers are formed they may radiate from the common centre in a tuft and not adhere laterally.

Occasionally in hanging drop cultures Stysanoid forms have arisen direct from germ hyphae, to the exclusion of the smaller type of solitary microconidiophore.

Heterothallism.

The irregularity of appearance of perithecia in cultures from loops of conidia, and their localised formation when they did appear, led to the hypothesis of heterothallism.

Single ascospore vegetations were therefore studied. With the exception of one abnormal culture (*vide infra*) these growths produced only normal conidial forms when grown alone.

They were next grown in pairs, transfers from two different growths being planted on opposite sides of each plate. Each culture of monosporous origin was grown with every other, and the experiments were repeated several times. The results showed that each of the monosporous growths belonged to one or other of two different complementary strains, called here for convenience *X* and *Y* strains. When two growths belonging to the same strain are grown together the mycelial mats, when they meet, extend into one another for a short distance. No other reaction occurs except a slightly more profuse production of aerial microconidia, in the common area, at the edge of each

mat. When the mycelia of unlike strains meet they also share a narrow common zone, which becomes dark in colour owing to a more than usually profuse production of macroconidia. Perithecia appear in this area. The two strains show no differences in morphology or behaviour in culture.

The following table shows the results obtained by growing vegetations derived from single ascospores in pairs, the + and − signs indicating the occurrence or non-occurrence of perithecia respectively.

		X					*Y*	
Vegetations		*D*	*E*	*G*	*H*	*J*	*F*	*K*
X	*D*	−	−	−	−	−	+	+
	E	−	−	−	−	−	+	+
	G	−	−	−	−	−	+	+
	H	−	−	−	−	−	+	+
	J	−	−	−	−	−	+	+
Y	*F*	+	+	+	+	+	−	−
	K	+	+	+	+	+	−	−

From original mixed material the two strains may be easily isolated by picking out single chains of aerial microconidia from the edges of young mats on agar plates.

The sterility of monosporous cultures and of mixed cultures of the same strain, and the regular appearance of perithecia in mixed cultures of unlike strains proves that the fungus is heterothallic.

This fact probably explains why the perfect form of *Thielaviopsis paradoxa* has not been definitely demonstrated by previous investigators. There are two possible alternative explanations. Care in isolating the fungus may have led to only one strain having been obtained. The extreme precaution of working with cultures of monosporous origin would definitely preclude the appearance of perithecia in cultures unless the cultures were deliberately mixed.

On the other hand it is possible that only one strain was present in the original material investigated. Such is frequent with other heterothallic fungi (*cf.* Shear and Dodge (9) on the genus *Neurospora*, and common experience with some Mucoraceae).

There is also a further possibility not based on the fact of heterothallism. Even when both strains are present perithecia may not be formed, for it is apparent that external conditions may inhibit their formation. No perithecia have been found in diseased coconut palms and pineapple in the Gold Coast, and in laboratory infections by mixed strains on pineapple and sugar cane perithecia have not been formed. Contaminations in cultures sometimes prevent the formation of perithecia, and the same condition may apply in nature. In plate cultures shallow medium inhibits, while deep medium permits luxuriant forma-

tion of perithecia. It seems probable that conditions of both nutrition and water-relation may be the factors concerned.

Very favourable conditions evidently exist in cacao husk heaps, the mucilaginous tissue providing suitable food; perithecia appear very abundantly in those husks which have been thoroughly soaked by rain, and in which water is still retained.

An Abnormal Monosporous Vegetation.

A series of cultures made from single ascospores included one abnormal form. Development of the mycelium was much slower than normal. No conidia of any kind were produced. The mycelium became yellow and then greenish brown with age. A few sclerotia were observed in the cultures, and some days later spherical pearly drops appeared on the summit of the "sclerotia."

On examination these bodies were found closely to resemble the bulbs of perithecia, but no beak was formed, only a circular ostiole, round which the colour of the bulb was olivaceous. Spores, very similar to ascospores in size and shape, were produced in large numbers in the bulb, terminally on very numerous fertile hyphae. These spores germinated freely in hanging drops and produced mycelium identical with the original. Early stages of germination closely resembled those of ascospores, but the mycelium quickly became contorted and tuberculate.

It is believed that this strain is a saltant. Similar germinations have twice been seen in hanging drops, where they remained sterile.

The fungus hitherto known as *Thielaviopsis paradoxa* (de Seynes) von Höhnel is now proved to be an Ascomycete. Having regard to the resemblance of both the perithecial and the endogenous conidial stages to the corresponding stages of *Ceratostomella adiposa* (Butl.) Sartoris and *C. fimbriata* (E. & H.) Elliot, it is evident that the fungus now under discussion should be placed in the genus *Ceratostomella*.

The conidial stage of the fungus was originally described as *Sporochisma paradoxum* by de Seynes, and the name *Ceratostomella paradoxa* is therefore proposed for the perfect stage.

Ceratostomella paradoxa Dade.

Perithecia gregaria, 1000–1500μ longa, bulbis immersis, globosis, hyalinis, 200–350μ diam., appendiculis brunneis, substellatiformibus vel coralliformibus; rostris atris nitidisque, apicibus hyalinis fimbriatisque, 800–1200μ longis, 30–40μ latis. Asci clavati, stipitati, fugaces, ca. 25μ longi, ca. 10μ diam.; sporae 8-nae, hyalinae, ellipsoidales saepe flexionibus inaequalibus, in matrice adipata immersae, 7–10μ longae, 2·5–4μ diam.

Sexi in propriis hyphis.

Forma conidialis—*Thielaviopsis paradoxa* (de Seynes) von Höhnel. Nomina idem valenta—*Sporochisma paradoxum* de Seynes (1886), *Chalara paradoxa*, Sacc. (1892), *Thielaviopsis ethaceticus* Went (1893).

The perithecia are gregarious, 1000–1500μ long; the bulbs are immersed, globose, hyaline, 200–350μ diam., with brown appendages which are rather stellate or ceralloid in form; the beaks are black and shining, with hyaline fimbriate tips, 800–1200μ long, 30–40μ diam. Asci are clavate, stipitate, fugitive, about 25μ long and 10μ diam.; ascospores in eights, hyaline, ellipsoid or frequently with unequally curved sides, in a fatty matrix, 7–10 × 2·5–4μ. The fungus is heterothallic.

Conidial form—*Thielaviopsis paradoxa* (de Seynes) von Höhnel, with the synonyms *Sporochisma paradoxum* de Seynes (1886), *Chalara paradoxa*, Sacc. (1892), *Thielaviopsis ethaceticus* Went (1893).

The writer is indebted to Professor S. F. Ashby and to Mr E. W. Mason, of the Imperial Bureau of Mycology, who provided information from otherwise inaccessible literature, and to the former for useful advice.

Summary.

1. *Thielaviopsis paradoxa* (de Seynes) v. Höhnel has been found in the Gold Coast in association with a Sphaeronemoid form.

2. The Sphaeronemoid fruit body has been shown to be a perithecium which bears very characteristic appendages, and produces very fugitive asci.

3. The identity of the perithecial form with the conidial forms of *T. paradoxa* has been proved in culture.

4. Work with vegetations originating from single ascospores has shown that the fungus is heterothallic.

5. The fungus is referred to the genus *Ceratostomella* and the new binomial *Ceratostomella paradoxa* is proposed.

References.

(1) Petch, T. *Thielaviopsis paradoxa* (de Seynes) v. Höhnel. Ann. Royal Bot. Gardens, Peradeniya, IV (1910), 511.

(2) Massee, G. On *Trichosphaeria Sacchari*. Ann. Bot. VII (1893), 515.

(3) Patterson, C. and Veihmeyer. Some fungus diseases of economic importance. I. Pineapple-rot caused by *Thielaviopsis paradoxa*. U.S. Dept. Agric., Bur. Plant Ind., No. 171. 1910.

(4) Elliot, J. A. The ascigerous stage of the sweet potato black-rot fungus. (Abstract) Phytopathology, XIII (1923), 56.

(5) Elliot, J. A. A cytological study of *Ceratostomella fimbriata* (E. and H.). Phytopathology xv (1925), 417.
(6) Sartoris, G. B. A Cytological study of *Ceratostomella adiposum* (Butl.) comb. nov., the black-rot fungus of sugar cane. Journ. Agric. Res. xxxv (1927), 577.
(7) Bunting, R. H. Year Book, Dept. of Agric. Gold Coast, p. 24. 1926.
(8) Dade, H. A. Economic significance of Cacao Pod Diseases. Bull. 6, Gold Coast Dept. Agric. 1927.
(9) Shear, C. L. and Dodge, B. O. Life histories and heterothallism of the red bread-mold fungi of the *Monilia sitophila* group. Journ. Agric. Res. xxxiv (1927), 1019.

EXPLANATION OF PLATES X–XII.

(All drawings were made with the aid of a camera lucida.)

PLATE X.

Fig. 1. Two perithecia of *Ceratostomella paradoxa* n.sp., showing relative size of bulb and beak, fimbriate apex of beak, extruded ascospore masses, and creeping hyphae with microconidiophores, which have ascended the beak. ×33.
Fig. 2. Appendages on the bulb of a perithecium. The base of the beak is the dark object in the upper left hand corner. ×270.
Fig. 3. Transverse section of beak. ×270.
Fig. 4. Longitudinal section of a young perithecium in which differentiation of the coiled hyphae has begun. ×270.
Fig. 5. Longitudinal section of a perithecium with young asci and free ascospores. Also two young perithecia, in one of which the cavity has formed; ascogenous hyphae in the centre of the cavity. (A conidium has been forced into the cavity during sectioning.) ×197·5.
Fig. 6. Longitudinal section of a perithecium with young asci and free ascospores, some of which can be seen in the beak. ×197·5.
Fig. 7. Longitudinal section of a perithecium. Maturing asci at the left. Some of the thin-walled storage cells at the base have not been exhausted. ×197·5.

PLATE XI.

Fig. 8. A large coloured microconidiophore, growing alone, of the same type as is found in the *Stysanus*, or coremial, form. ×375.
Fig. 9. A normal small type microconidiophore for comparison with Fig. 8. ×375.
Fig. 10. The hyphal system forming the basis of a small *Stysanus* body. *C, C*, basal segments of large microconidiophores. ×390.
Fig. 11. Production of macroconidia on mycelium from a germinating microconidium, without a previous microconidial stage having occurred. ×390.
Fig. 12. A macroconidiophore produced directly from a germinated microconidium without previous production of microconidia. ×390.
Fig. 13. A macroconidiophore produced from the tip of a microconidiophore which has not functioned as such. ×390.
Fig. 14. The germination of microconidia which have formed epispores, showing the ruptured epispores. ×390.
Fig. 15. Anastomoses between ascospore germ hyphae. ×390.
Fig. 16. Asci from crushed living perithecia. ×390.
Fig. 17. A bundle of eight ascospores, with fatty investment, from a crushed perithecium. ×390.
Fig. 18. Maturing asci, drawn from serial sections, one showing biseriate arrangement of ascospores. ×842.
Fig. 19. Mature asci, from serial sections. ×842.
Fig. 20. The fimbriate hyaline apex of a perithecium. ×425.
Fig. 21. Appendages from perithecia. ×375.

PLATE XII.

Fig. 22. Germinating ascospores, showing primary, secondary and further germ hyphae, and progressive swelling of spore. ×390.
Fig. 23. Formation of microconidiophores on mycelium from germinated ascospores. ×390.
Fig. 24. Secondary growth of microconidiophores. *A*, functioning microconidiophore. *B*, resumed growth of same conidiophore after discharge of conidia. ×390.
Fig. 25. Production of microconidia and (later) of macroconidia from mycelium of germinated ascospore. The microconidiophore exhibits two stages of activity, the successive tips being marked *A* and *B*. The first batch of conidia has in most cases formed coloured epispores, the second has in most cases germinated. A third phase of growth is in progress (*C*). ×390.
Fig. 26. An ascospore germination similar to that of Fig. 25. A second phase of growth of the microconidiophore is in progress. ×390.
Fig. 27. Small microconidiophores produced direct from ascospores without a previous phase of vegetative growth. ×390.

FURTHER STUDIES OF THE BROWN-ROT FUNGI.

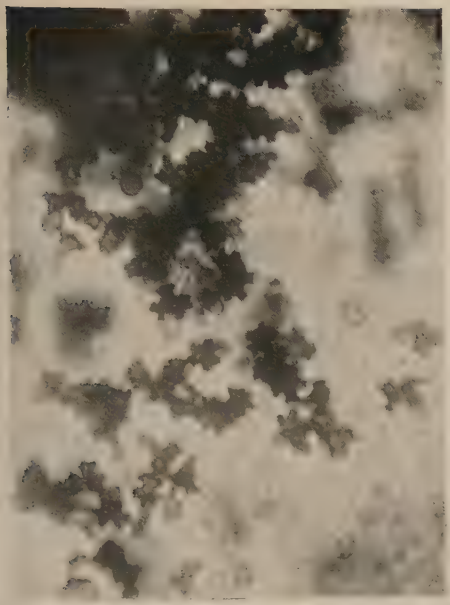
III. NOMENCLATURE OF THE AMERICAN BROWN-ROT FUNGI: A REVIEW OF LITERATURE AND CRITICAL REMARKS.

By H. Wormald, Horticultural Research Station, East Malling, Kent.

Introduction.

In the previous article of this series (20) the distribution of the brown-rot fungi was discussed and particular attention was drawn to the fact that the brown-rot *Sclerotinia* prevalent in North America, Australia and New Zealand, is distinct from *S. fructigena* and *S. cinerea*, the two species of fruit-rotting fungi common in Europe. It was pointed out that this American form closely resembles *S. cinerea* of Europe in the morphology of its ascigerous and conidial fructifications, but that the two are not identical, can be readily shown by cultural methods. Norton and Ezekiel (10) considered that the differences they found in cultures were sufficient for the common American brown-rot fungus to be a distinct species, and named it *Sclerotinia americana*. For some years previous to Norton and Ezekiel's studies the fungus was considered to be *S. cinerea*, while in a recent paper, Roberts and Dunegan (15) maintain that "Its name should be *Sclerotinia fructicola*," the name given to a Discomycete by Winter.

Since the publication of Roberts and Dunegan's paper a number of workers in this country and in America have asked my views on the question. It is thought therefore that a note



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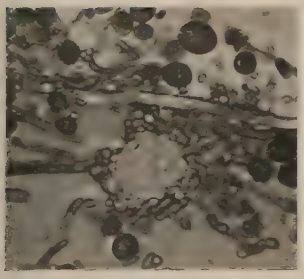

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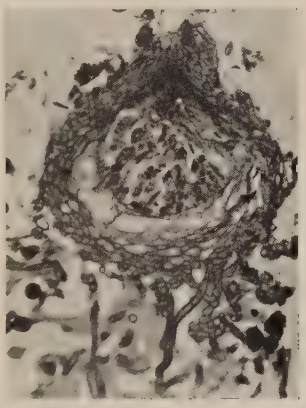

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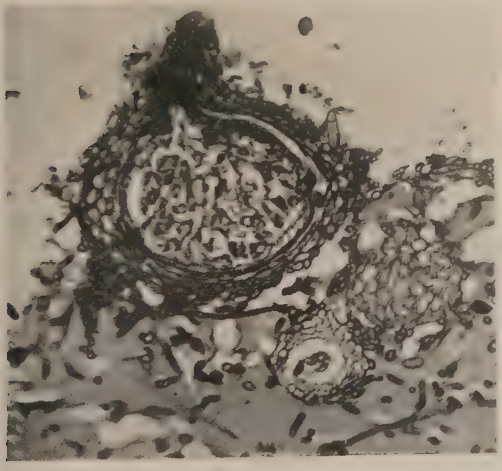

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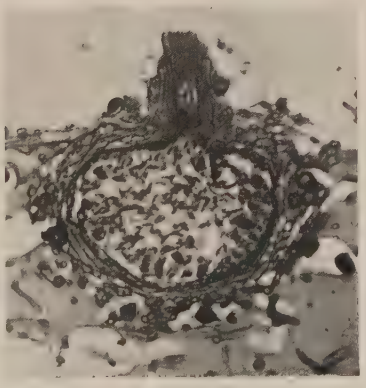

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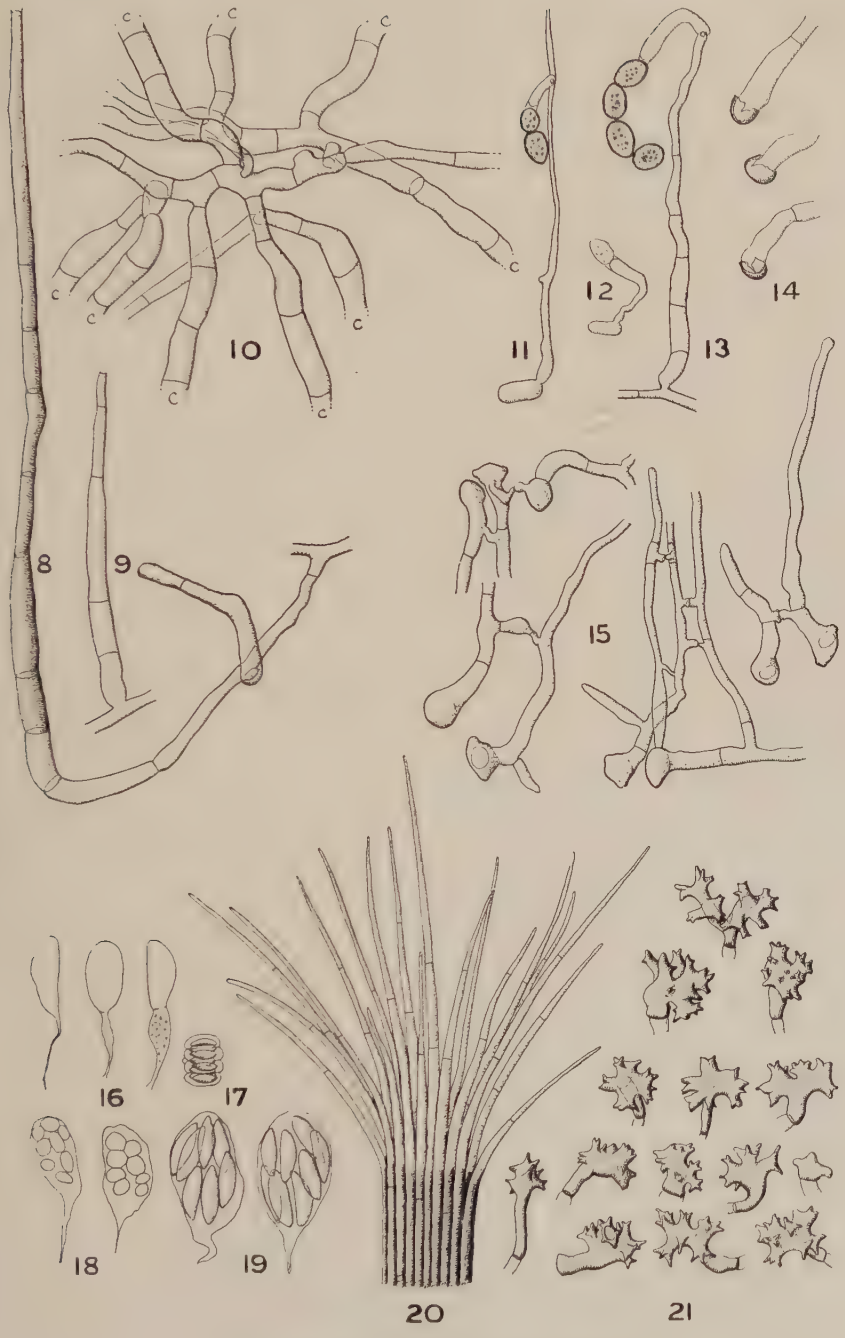
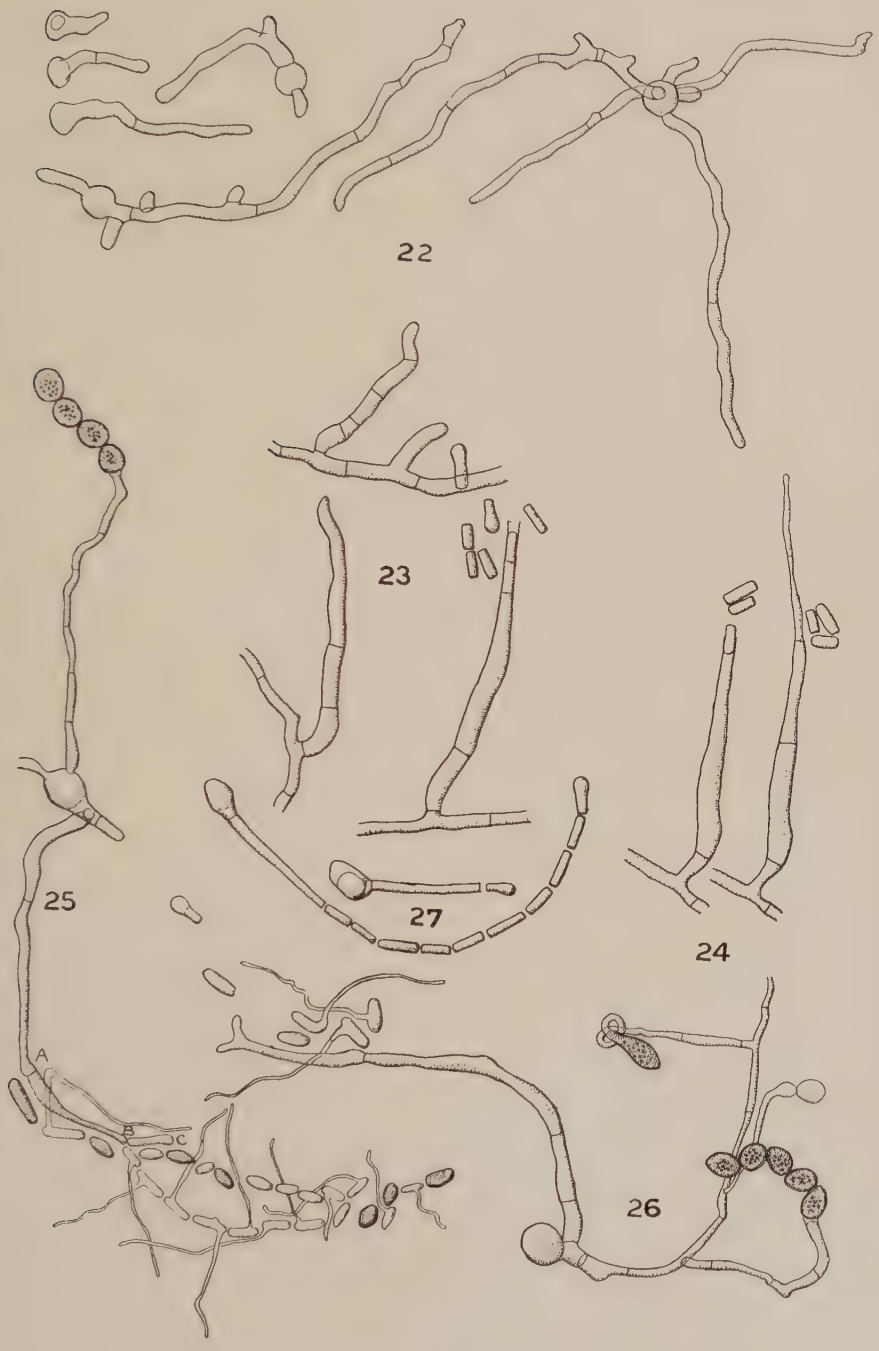
CERATOSTOMELLA PARADOXA DADE



CERATOSTOMELLA PARADOXA DADE



CERATOSTOMELLA PARADOXA DADE

may not be out of place, especially as certain statements by Roberts and Dunegan cannot pass without comment.

As the papers bearing on the nomenclature of this fungus are very scattered a summary of the history of the controversy may help plant pathologists in Europe to realise the situation as it affects American workers. The subject is not without interest to workers in Britain for a study of the distribution has shown that the common American fruit-rotting fungus is not at present found here, and the intensive study of the organism, that the discussions have stimulated in America, is adding to the evidence showing that this destructive fungus is distinct, not only culturally but also in its mode of parasitism from the fruit-rotting Sclerotinias of Britain and the Continent.

Historical.

The conidial fructifications of the brown-rot fungi are familiar to all mycologists and plant pathologists in those regions where fruit trees of the species of *Prunus* and *Pyrus* are cultivated. A survey of the literature bearing on the earlier records of the monilioid stages of the fungi, and of the brown-rot diseases generally, has appeared in an earlier paper (17). The apothecia of the *Sclerotinia* stage are far less common than the conidial fructifications and in Europe have rarely been found. The present discussion refers particularly to the value of the morphology of the apothecia in diagnosing the brown-rot fungi.

In 1883 Winter described a Discomycete, which had been found on decayed peaches in Pennsylvania and sent to him by Mr Eugene A. Rau, as a new species under the name *Ciboria fructicola*; later it was transferred to the genus *Sclerotinia* by Rehm and it appears in Saccardo's *Sylloge Fungorum*, XVIII, as *Sclerotinia fructicola* (Winter) Rehm.

Norton in 1902 described a Discomycete which he found growing out from mummied peaches in Maryland, and showed its connection with the common American fruit-rotting *Monilia* which at the time was thought to be identical with *Monilia fructigena* of Europe. Norton therefore named this Ascomycete *Sclerotinia fructigena*.

In 1905, however, Aderhold and Ruhland found, in Germany, apothecia which they proved to be the ascigerous stage of *Monilia fructigena* as defined by Woronin (21), and, comparing this with preserved material obtained from Norton, found that Norton's fungus was not *S. fructigena*. They concluded that the American specimens were the ascigerous stage of *S. cinerea*, the other common brown-rot fungus of Europe, but as it has since been shown that *S. cinerea* of Europe and the common brown-

rot fungus of America are not identical this conclusion cannot now be maintained.

Since that time the ascigerous stage of the American brown-rot *Monilia* has been found frequently and descriptions of the apothecia have been given by a number of workers, *e.g.* Reade (13), Pollock (11), Matheny (8) and Bartram (3). The first two retained the name *Sclerotinia fructigena* for the fungus. Matheny, comparing his material with cultures obtained from Europe, concluded that the fungus was not *S. fructigena* but that "it agrees more nearly with *S. cinerea* and should be referred to that species," and, until recently, that name was fairly generally adopted for the American fungus.

In 1921 I described apothecia which had developed from mummied plums in England. By cultural methods and by inoculations on fresh plums I was able to prove that these were the apothecial stage of *Monilia cinerea* and therefore referred the fungus to *Sclerotinia cinerea* (Bon.) Schröter. I also pointed out that "the Sclerotinias recorded for Europe as occurring on apricots, cherries and plums show no essential morphological differences" with respect to their apothecial fructifications. The dimensions of the asci and ascospores of *S. cinerea* showed considerable variation but they were found to be of the same order as those obtained by a number of American workers for the American fruit-rotting *Sclerotinia.*

In 1917 the writer, after comparing a number of American strains with *Monilia* (*Sclerotinia*) *cinerea* as found in Britain and on the Continent, showed that the fungus generally distributed in the United States could readily be distinguished by cultural methods and referred to it as *Monilia cinerea* forma *americana.* These results from cultural studies were confirmed and supplemented by Norton and Ezekiel (10) who decided that the common American brown-rot fungus should be raised to specific rank and named it *Sclerotinia americana* (Wormald) Norton and Ezekiel.

From 1915 onwards workers in Oregon and California observed that in those states there was a type of *Monilia* infection unlike the ordinary brown-rot generally distributed in the United States. Thus Jackson in 1915 described a pear disease in Oregon caused by a species of *Monilia.* This fungus was studied by Posey (12) who found that it was different from the more common American brown-rot fungus (thought at the time to be *Sclerotinia cinerea*) and from *Monilia fructigena.* Howard also noticed that brown-rot attack in California was unlike that prevailing in the eastern states for in 1920 he wrote (6): "While brown rot is comparatively new to California, it is one of the oldest diseases of stone fruits in the eastern and southern

states and in Europe. Strangely enough, the brown rot is a midsummer disease in the eastern states, and never attacks anything but the fruit. In California it does its chief damage by attacking the flower clusters and then quickly killing the fruiting spurs....The disease appears in early spring, just after the trees are out of bloom, first attacking the blossoms, then spreading into the fruit spurs. The flower clusters are quickly destroyed, and the spurs and sometimes even the older wood are killed in a very short time."

As already mentioned in a previous communication (20) I received a number of specimens from Dr Howard in 1920 and 1921 and each yielded a fungus which proved in culture to be indistinguishable from *S. cinerea* of Europe.

Barss in 1923, called attention to "two related disease-producing fungi" in Oregon. He observed differences in the field and in cultures as shown by the following quotation: "The true brown-rot disease which is so widespread in the United States is caused by a fungus usually designated by the scientific name *Sclerotinia cinerea* (Bon.) Wor. It is this ordinary brown-rot fungus that causes the severe attacks of fruit rot of stone fruits in Oregon. It often causes blossom blight as well. There is, in addition, a closely related fungus common on the Pacific Coast which often causes very severe attacks of blossom and spur blight and twig cankers on all kinds of stone fruits and on certain varieties of pears, but which causes little rotting of fruit....The complete life-history of this parasite is not yet known. In tests it failed to produce the apothecial (spore-cup) stage under conditions that gave abundant development of this stage with the ordinary brown-rot fungus. It produces spores in chains very closely resembling those of the ordinary brown-rot, but it differs from the latter in the appearance and manner of spore production on the host plant. In artificial cultures it has also proved to be very different from the common brown-rot fungus or other described species. We have, therefore, considered it a new species and have assigned to it the name *Monilia oregonensis* Barss and Posey. The disease caused by it will be referred to as *Monilia* blight to distinguish it from the true brown-rot disease."

These observations of Howard in California and of Barss and Posey in Oregon are of particular interest in showing that, in America, there are two brown-rot fungi which can be distinguished not only in culture but also in their mode of attack on the host plants. Barss's description and figures suggest that "this ordinary brown-rot fungus" which is "usually designated by the scientific name *Sclerotinia cinerea*" is the fungus *Sclerotinia americana* of Norton and Ezekiel and that *Monilia*

oregonensis is identical with the conidial stage of *S. cinerea* of Europe. This conclusion has been supported by Ezekiel (5) and confirmed by myself (20) with cultures from Professor Barss. It is significant that the differences observed by Barss and Posey were such as to induce them to consider the two as distinct species even before the more detailed cultural studies of Ezekiel were published.

That Winter's fungus might have some connection with brown-rot appears to have been overlooked for some years until in 1909, Pollock pointed out that in Winter's description the dimensions of asci and ascospores were very similar to those obtained by Reade in 1908 for the ascigerous stage of the American brown-rot fungus, and stated that, on grounds of priority, the correct name of the fungus should be *Sclerotinia fructicola* (Winter) Rehm. "In 1920, Pollock at the annual meeting of the Botanical Society of America submitted data to show that the species of *Sclerotinia* common on American stone fruits is distinct from either *S. fructigena* or *S. cinerea* of Europe*," and he again referred to Winter's description.

Roberts and Dunegan (14) examined from Rau's collection at the Office of Pathological Collections of the United States Department of Agriculture "what is evidently a part of the type collection of Winter's *S. fructicola*." Paying particular attention to the size of asci and ascospores they compared the dimensions shown by the herbarium specimens with those given by Winter and with those obtained, from fresh specimens, by themselves and other workers.

These results together with those of Reade, Pollock, Matheny, Roberts, and Dunegan for fresh specimens of the American brown-rot fungus are given in a table† that "shows a series of measurements, exclusive of Rau's material, in which the range for asci is from 125 to 215μ in length and from 5·7 to 13·3μ in width. For ascospores the range is from 6·0 to 15μ in length and from 4 to 8μ in width. These measurements agree fairly well with those of the type material of *S. fructicola*." They conclude, "It therefore seems certain that in 1883 Rau collected and Winter described the species of *Sclerotinia* which Norton in 1902 showed to be the ascogenous stage of our common brown-rot fungus." At that time Roberts and Dunegan believed that "the known differences between the American and European forms are not sufficiently great to warrant considering the two forms as separate species. The name *Sclerotinia cinerea* (Bon.) Schröt. is preferred by the authors."

The critical cultural studies of Ezekiel (4), however, added further evidence for considering the American fungus as specifically distinct from *S. cinerea*; he retained the name *S. americana*

* Quoted from Roberts and Dunegan (14). † See page 201.

in preference to Winter's *S. fructicola* as "this name cannot be assigned to any of the species now known, since the description does not differentiate between them." In that paper Ezekiel first showed that the "Monilia blight" fungus of Oregon and California resembled *S. cinerea* of Europe. In 1925 the same author offered further evidence for the conclusion that *Sclerotinia cinerea* (Bon.) Schröt. was present in the Pacific coastal regions. With further reference to Winter's fungus he wrote: "If means of distinguishing *S. americana* from *S. cinerea* by the apothecial characteristics should be worked out, we might then be able to identify the dried specimens of Winter more definitely with *S. americana*, which would then properly be called *S. fructicola*. For the present, it seems preferable to use Wormald's name *americana*, which was published with the first description that differentiated the American species from the earlier known European forms."

In a more recent paper Roberts and Dunegan (15) criticise Ezekiel's remarks in these words, "The authors fail to agree with Ezekiel's reasoning. They do not feel that the problem of distinguishing between apothecia of *Sclerotinia cinerea* of Europe and the apothecia of the common American form has anything to do with the problem of the identity of the latter with Rau's material of *Sclerotinia fructicola*. They are two separate and distinct problems. The writers' studies have shown that the apothecial characters of *Sclerotinia fructicola* agree very well with those of the species of *Sclerotinia* commonly found on mummied peaches in America at the present time." From a consideration of the field observations of Barss and from their own examination of material sent to them from California, they were led "to recede from the position taken in their previous paper, *i.e.* that they preferred to retain *Sclerotinia cinerea* as the name for the fungus causing the common fruit-rot in America. The physiological differences which they hesitated to accept as criteria for the separation of the species have been shown to persist when the two species occur naturally under environmental conditions similar to those of Europe. Moreover it is possible to separate the two in the orchard or in herbaria...the authors feel that the common American brown-rot fungus is to be considered a distinct species. Its name should be *Sclerotinia fructicola*, the first name applied to it and one accompanied by an adequate description."

Discussion.

That *Sclerotinia fructicola* may be the apothecial stage of the common American brown-rot fungus is not improbable but the evidence, as it stands, is not conclusive. In the first place it is not known that Winter's species is even a monilioid brown-rot

fungus as apparently no cultural or inoculation experiments were carried out with it. From the original description*, however, it would appear to belong to the *Stromatinia* section of the genus *Sclerotinia* in which the brown-rot fungi are included. Roberts and Dunegan (15) are not oblivious to the importance (in these fungi) of connecting up the ascospores with the corresponding conidial fructifications, and in proposing certain "dicta as a guide in the study of the validity of the species" they include one which runs, "Whenever possible the connection between the species of *Sclerotinia* and the species of *Monilia* must be demonstrated if it is to be accepted."

In my opinion the weakest point in Roberts and Dunegan's argument is that they state, "The writers' studies have shown that the apothecial characters of *Sclerotinia fructicola* agree very well with those of the species of *Sclerotinia* commonly found on mummied peaches in America at the present time," without meeting Ezekiel's objection that the original description does not differentiate between species now known. For example they omit to point out that the characters quoted, also "agree very well" with those published (19) for *S. cinerea*. There is now good evidence as shown above for believing that *Sclerotinia cinerea* (Bon.) Schröt. is itself present in the United States, and Roberts and Dunegan themselves now regard it and the more common American brown-rot fungus as distinct species. It is therefore necessary for them to show that Winter's fungus cannot at any rate be *S. cinerea* if they refuse to allow Ezekiel's objection.

I am entirely in sympathy with Ezekiel as opposed to Roberts and Dunegan in their contention that a comparative study of apothecia of *S. cinerea* and of the common American brown-rot fungus has nothing to do with the problem of the identity of the latter with *S. fructicola*. The two fungi undoubtedly closely resemble one another in the morphology of their apothecia and it has not yet been shown that they can be distinguished by an examination of these only. Since they are to be found together in the western states there should be an opportunity for a careful comparative study of fresh material of apothecia. Then if differences could be detected under such conditions the more exacting comparison with the herbarium specimens of *S. fructicola* might be profitable.

To illustrate the present *impasse* the table on which Roberts and Dunegan chiefly rely for identifying *S. fructicola* with the common American brown-rot fungus is here reproduced, together with figures taken from a table by the writer showing dimensions of asci and ascospores of *S. cinerea*.

In Roberts and Dunegan's description of Winter's type

* "Stipes...ex epicarpio in corporem sclerotioideum fusco-atrum transformato oriens."

"These measurements, regardless of the names given, are of Sclerotinias from Stone Fruits in America."

Investigator	Date	Name given to fungus	Host	Asci	Ascospores
Winter	1883	*Ciboria fructicola*	Peach	130 to 160 ×8 to 8·5	10 to 12·5 ×4 to 5·5
Reade	1908	*Sclerotinia fructigena*	Peach	125 to 215 ×7 to 10	10 to 15 ×5 to 8
Pollock	1909	*Sclerotinia fructigena*	Stone fruits	130 to 179 ×9·2 to 11·5	11·4 to 14·4 ×5 to 7
Matheny	1913	*Sclerotinia cinerea*	Peach	135 to 190 ×6·9 to 10·5	10·5 to 14·5 ×5·2 to 7·5
Matheny	1913	*Sclerotinia cinerea*	Plum	135 to 173 ×6·8 to 10·8	8·3 to 14·2 ×5 to 7·4
Roberts	1920	*Sclerotinia cinerea*	Peach	152 to 176 ×8 to 10	6 to 15 ×4 to 8
Dunegan	1922–23	*Sclerotinia cinerea*	Peach	130 to 186 ×5·7 to 13·3	9·5 to 14 ×5·7 to 7·6
Dunegan	1924	*Sclerotinia fructicola* (Winter's type material.)	Peach	117 to 161 ×5·7 to 9·5	6·8 to 13·1 ×3·4 to 6·8

Corresponding figures for S. cinerea (*Bon.*) *Schröter in its restricted sense as used in the present paper.*

Wormald	1920	*Sclerotinia cinerea*	Plum	Asci with monostichous spores. 124 to 188 ×7·5 to 10·5 Average 153·4 ×8·7 Asci with distichous spores 162 to 226 ×10 to 13·5 Average 192 ×11·25	7 to 19 ×4·5 to 8·5 Average 12·5 ×6·2

material the arrangement of the ascospores within the asci is given as "end to end or, as in some cases, with their long axes at an angle to the long axis of the ascus, that is, seriate"; this arrangement therefore corresponds to that in "Asci with monostichous spores," and the dimensions of the asci must be compared accordingly. It is obvious that the figures as they stand offer no evidence whatever that *S. fructicola* is morphologically more nearly related to the common American brown-rot fungus than it is to *S. cinerea*.

One fact in favour of Roberts and Dunegan's view, and one which they do not make use of, is that, so far as is known, *Sclerotinia cinerea* is, at present, confined (in North America) to the Pacific coastal regions of California, Oregon and Vancouver Island, and is not known in the eastern states. If further investigation shows that, in North America, *S. cinerea* is really restricted to the Pacific coast the chances that it was present in Pennsylvania in 1883 are very remote.

Whether there are other species of *Sclerotinia* in America to which Winter's description might equally apply is outside the scope of this article, and must be decided by American systematists.

Another point of view is that of Honey* who is engaged in compiling a monograph of the American monilioid Sclerotinias. In his opinion the fungi *S. americana*, *S. cinerea* forma *Pruni* and *S. cinerea* forma *Mali*, should all be considered as biologic strains of one species for which he would retain the name *S. fructicola*. His reasons for such a conclusion will be awaited with interest for it has to meet the objections noted above, *i.e.* that Winter's fungus was not connected up with a *Monilia* stage, and that *S. americana* and *S. cinerea* can be recognised as different both in the field and in the laboratory.

Conclusions.

In the present state of our knowledge, since the two brown-rot fungi of America are readily distinguishable in culture and there is increasing evidence that they differ in the mode of parasitism, they should be considered as distinct species. Moreover, the evidence (as pointed out above) that Winter's fungus is the *Sclerotinia* stage of the common American brown-rot fungus, is inconclusive, and at present with Ezekiel I maintain that, as *S. cinerea* and the more common American brown-rot fungus are both found in North America, attempts should be made to obtain an exhaustive examination of the ascophores of the two fungi in order to ascertain whether there are any morphological characters by which they can be distinguished. If any such differences can be detected it should then be possible to deter-

* Communicated to the writer by letter.

mine whether Winter's specific name can be retained as a valid one for the brown-rot fungus prevalent throughout the United States. Until this is done the use of the name *Sclerotinia americana* is preferable to distinguish that fungus from *S. cinerea**.

A Supplementary, Economic, Note.

As already pointed out, one result of the controversy discussed in this article has been to show clearly that the brown-rot fungus generally distributed throughout the fruit-growing regions of North America is distinct from the two common species of fruit-rotting Sclerotinias found in Britain. The American fungus is very destructive to the stone-fruits not only in the United States and British North America, but also in some parts of Australia and in New Zealand, and it is very undesirable that it should be introduced into this country. Until recently its introduction on imported fruit was not perhaps a serious menace, since apples, which are imported on a large scale, are not seriously attacked by *S. americana*. On the other hand, the brown-rot of peaches caused by this fungus is one of the worst fruit diseases in America. Modern methods of conserving fresh fruit during transport make it possible to import peaches, and recently consignments have reached this country from America. Diseased specimens from two of these consignments (one from Georgia, the other from Ontario), were sent to me and found to be infected with brown rot, and *S. americana* was isolated from each of them. There appears then to be a real risk of introducing into this country a destructive fruit-rotting fungus which at present does not occur here.

Summary.

A survey is presented of the literature on the nomenclature of the brown-rot fungus generally distributed throughout the fruit-growing regions of the United States and Canada. The names that have been applied to it are: *Sclerotinia fructigena* (Pers.) Schröt.; *Sclerotinia cinerea* (Bon.) Schröt.; *Sclerotinia cinerea* forma *americana* Wormald; *Sclerotinia americana* (Wormald) Norton & Ezekiel; *Sclerotinia fructicola* (Winter) Rehm.

The fungus is undoubtedly more nearly related to *S. cinerea* than to *S. fructigena* which is not known in North America.

* While this article was in the press a paper by Honey appeared (*Mycologia*, XX, 127–157, 1928) in which he discusses in detail the systematic position of the genus *Sclerotinia* and in particular the relation of the monilioid Sclerotinias to the other species included in this genus. Because of "the distinctive characteristics of the monilioid species of *Sclerotinia*" he introduces the name *Monilinia* for a genus to include those species, and takes as his type Winter's fungus *Sclerotinia fructicola*, giving it therefore the name *Monilinia fructicola* (Wint.) Honey. Whether this standpoint, which has interesting issues, will be approved by other systematists remains to be seen. It is unfortunate, however, that the material taken as the type was not connected up with a conidial form, since the monilioid conidial stage is one of the chief characteristics of the proposed new genus.

The results of cultural work, and of field observations on the injury caused by this fungus and by *S. cinerea*, are now generally accepted as sufficient evidence for considering them as distinct species.

The main theme of the present paper is to show that descriptions of Winter's *S. fructicola* do not differentiate between *S. cinerea* and Norton & Ezekiel's *S. americana*, both of which are found in North America.

In the present state of our knowledge, therefore, the author prefers the name *Sclerotinia americana* for the more common brown-rot fungus of America.

REFERENCES.

(1) Aderhold, R. und Ruhland, W. Zur Kenntnis der Obstbaum-Sklerotinien. Arb. Biol. Abt., Land- u. Forstw. am Kaiserl. Gesundheitsamte, IV (1905), 427–442.

(2) Barss, H. P. Brown-rot and Related Diseases of Stone Fruits in Oregon. Circ. 53. Oregon Agric. Coll. Expt. Sta. 1923.

(3) Bartram, H. E. A Study of the Brown Rot Fungus in Northern Vermont. Phytopath. VI (1916), 71–78.

(4) Ezekiel, W. N. Fruit-Rotting Sclerotinias. II. The American Brown-Rot Fungi. Univ. of Maryland Agric. Expt. Sta. Bull. 271 (1924), 87–142.

(5) —— Presence of the European Brown-Rot Fungus in America. Phytopath. XV (1925), 535–542.

(6) Howard, W. L. Brown Rot of Apricots and Its Prevention. Better Fruit, XV (July, 1920), 7.

(7) Jackson, H. S. Notes, Observations and Minor Investigations on Plant Diseases. Pear Canker, *Monilia* sp. Oregon Agric. Expt. Sta., Bienn. Crop and Pest Rpt. 1913–14, II (1915), 271–2.

(8) Matheny, W. A. A Comparison of the American Brown-Rot Fungus with *Sclerotinia fructigena* and *S. cinerea* of Europe. Bot. Gaz. LVI (1913), 418–432.

(9) Norton, J. B. S. *Sclerotinia fructigena*. Trans. Acad. Sci., St Louis, XII (1902), 91–97.

(10) Norton, J. B. S. and Ezekiel, W. N. The name of the American brown-rot *Sclerotinia* (Abst.). Phytopath. XIV (1924), 31–32.

(11) Pollock, J. B. Notes on Plant Pathology. Mich. Acad. Sci., Rpt. II (1909), 48–54.

(12) Posey, G. B. Studies of *Monilia* blight of fruit trees. Science, XLII (1915), 583.

(13) Reade, J. M. Preliminary Notes on some Species of *Sclerotinia*. Annales Mycol. VI (1908), 109–115.

(14) Roberts, J. W. and Dunegan, J. C. The Fungus causing the common Brown Rot of Fruits in America. Journ. Agric. Res. XXVIII (1924), 955–960.

(15) —— —— Critical Remarks on Certain Species of *Sclerotinia* and *Monilia* associated with Diseases of Fruits. Mycologia, XIX (1927), 195–205.

(16) Winter, G. Ueber einige nordamerikanische Pilze. Hedwigia, XX (1883), 67–72, 129–131.

(17) Wormald, H. The "Brown rot" diseases of fruit trees, with special reference to two Biologic Forms of *Monilia cinerea* Bon. I. Ann. Bot. XXXIII (1919), 361–404.

(18) —— II. Idem. XXXIV (1920), 143–171.

(19) —— On the Occurrence in Britain, of the Ascigerous Stage of a "Brown Rot" Fungus. Ann. Bot. XXXV (1921), 125–135.

(20) —— Further Studies of the Brown-rot fungi. II. A Contribution to our Knowledge of the Distribution of the Species of *Sclerotinia* causing Brown-Rot. Ann. Bot. XLI (1927), 287–299.

(21) Woronin, M. Ueber *Sclerotinia cinerea* and *Sclerotinia fructigena*. Mém. Acad. Imp. Sci., St Pétersbourg, sér. 8, X (1900), Phys.-Math. 1–38.

THE LIFE-HISTORY AND CYTOLOGY OF A NEW SPECIES OF OLPIDIUM; OLPIDIUM RADICALE SP.NOV.

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(With Plates XIII–XV.)

1. Introduction.

The parasitic fungus which is the subject of this paper was found in the roots of *Veronica Beccabunga* growing in the low-lying meadows near Dunton Green, Kent. For some years it has appeared regularly in this locality although it has not been observed in any other part of the country. During the summer of 1927, however, although many roots were examined, the fungus was found to be almost extinct, and the possibility that it was dying out made it desirable that the life-history and cytology, so far as they have been worked out, should be placed on record.

Material had been collected for the past four years periodically throughout each year, so that a considerable quantity of diseased roots was available. Living plants of *Veronica Beccabunga* containing the parasite had also been successfully grown in bell-jars in a greenhouse. It was during an examination of these that it was found that the fungus was able to infect the roots of other species growing in the bell-jars. Various grasses such as *Poa annua*, became heavily infected, and later, seedlings of *Lepidium sativum* growing near by, and sometimes watered with the water from the bell-jars, contracted the disease. Although no cross inoculation experiments were conducted it is concluded that the fungus is not restricted to a single host.

Roots of other plants such as *Ranunculus bulbosus*, *Alisma Plantago-aquatica* and *Poa annua* growing associated with *Veronica Beccabunga* in the meadows at Dunton Green were never found to be attacked and, it seems that under natural conditions where the plants are growing actively and where plenty of healthy plants of *V. Beccabunga* are available, the fungus does not attack the roots of other plants; it is only when the quantity of available food is reduced, or when the vitality of the host plant is lessened that this occurs. It is important to notice that *Olpidium radicale* shows a distinct discrimination between the roots of various possible hosts, with a decided preference for those of *V. Beccabunga*.

On the other hand, roots of *V. Beccabunga* collected from

various parts of the country have been examined, but no sign of the fungus has been observed. The roots of *V. Beccabunga* have been shown (7) to be frequently attacked by *Ligniera Junci*, but, whereas this parasite occurs sparingly in various places, *O. radicale* is entirely restricted to two or three meadows at Dunton Green. It has been previously pointed out (7) that something in the soil in the neighbourhood of Sevenoaks, Kent, appears to favour the growth of parasitic root fungi. The soil of these fields is distinctly acid, heavily charged with iron and resting on the Gault. It is thought probable that these features collectively are beneficial to the growth of *O. radicale*.

2. Methods.

Roots of *Veronica Beccabunga* containing the fungus have been studied both fixed and also in a living condition. Though the examination of living material has not enabled us to observe any conjugation of zoospores, actively swimming ones have been seen on several occasions. The actual penetration of the cell wall of a root hair by a zoospore has been seen.

Various fixatives have been employed, the best results being obtained with Flemming's weaker solution, and Bouin's Fluid. All the more recent collections were fixed with the latter solution. The material was usually fixed in the field, but it was found that material brought in a damp condition into the laboratory in tins, and fixed as much as an hour after collecting, was in no way harmed. Frequently the roots were left in warm water for a few hours before fixing to promote activity and in the hope of inducing nuclear division in the fungus.

Slides were prepared without sectioning, using the method which was found successful with *Ligniera Junci* (7). Both lactophenol and balsam mounts were made; the former, stained with cotton blue did not bring out the cytological detail very satisfactorily and were used only in confirmation of morphology. Roots stained in Heidenhain's haematoxylin proved most suitable for cytology, and slides prepared in this way were used for all the critical observations.

3. Historical.

Since the formation of the genus *Olpidium* by Braun in 1855 a considerable number of species have been figured and described. Their habitat is very variable; many are found in the cells of fresh-water algae, a few occur in species of *Saprolegnia*, others are found in the pollen grains of higher plants, while a few have been recorded in the roots of Phanerogams. Of these last the more important are *O. Brassicae* Woron.; *O. Salicorniae* Němec; *O. simulans* de Bary & Woron.; and *O. Viciae* Kusano. Fairly

full accounts of these have been published. In 1878 Woronin described *O. Brassicae* and showed that the sporangia form numerous exit tubes through which the zoospores are liberated. Since that time numerous papers have appeared. In 1912 Němec described further details of the cytology, and brought forward some interesting data on the type of nuclear division. More recently Guyot (20) has compared the structure of this species with that of *Asterocystis radicis* which he found occurring in the same roots.

In 1911 Němec described another species, *O. Salicorniae*, from the roots of *Salicornia herbacea*. One of the chief points of interest in this species is the almost complete absence of exit tubes, but in the structure and division of the nucleus it agrees closely with his results in *O. Brassicae*.

In the following year Kusano (22) published his excellent paper on *O. Viciae*. This species is particularly remarkable in its methods of sexual reproduction. Its cytology agrees very much with what Němec had previously described. *O. Viciae* shows exit tubes very poorly developed and often almost absent. This species also compares very closely with the one to be described where, however, the exit tubes are almost completely absent.

4. Life-History and Cytology.

The fungus invades the host tissues by means of free-swimming zoospores, which are frequently to be found in the water associated with the roots of *Veronica Beccabunga*. They have been watched repeatedly but no evidence of any conjugation has been obtained. The penetration of the root hairs has been seen, but it was never possible to make drawings during the process.

The zoospore itself is a small pear-shaped body 7–10μ long by 3–4μ in diameter (Pl. XIV, fig. 2). It possesses a single flagellum, about twice as long as the zoospore, which trails along behind, while the zoospore is swimming. When entry is about to occur the zoospore becomes attached to the root hair, withdraws its flagellum, and then an infection thread is put out which passes through the thin cell wall and gradually a vesicle is formed on the inside into which the contents of the zoospore pass. Once inside the cell the zoospore may become active again and may continue to swim about within the root hair for a long time, with the aid of its freshly developed flagellum (Pl. XIV, fig. 1). It is impossible to say how long this activity may continue; on one occasion a root hair containing a zoospore was watched for over three hours, and was still active. As the zoospore was already within the root hair when the slide was mounted no estimation of the duration of activity can be made.

In the early stage the sporangium (Pl. XIV, figs. 3, 4, 5) is invariably uninucleated, but concurrently with growth the nucleus divides into two and successive divisions follow rapidly. The method of nuclear division is definitely mitotic, though the divisions often appear very irregular and suggest a kind of amitosis. Sometimes, however, the details can be made out (Pl. XIV, fig. 9). In the example figured the spindle was quite clearly defined and distinct chromosomes were visible. The spindle here, although slightly elongated, was not nearly so attenuated as it frequently appears.

During the whole period of growth the sporangium is surrounded by a well-marked cell wall composed of cellulose, which is invariably thin during the early stages.

There appear to be two possibilities for the future development of a uninucleated sporangium. Frequently, especially if two are present in the same cell of the host, they both increase in size without any nuclear division; the smaller of the two then approaches the larger and a beak-like process is put out, which comes into contact with the wall of the larger one. It has not been found possible to observe any actual process of fusion, but cells have been seen in which two such sporangia were present one containing two nuclei while the other, so far as could be observed, was devoid of any contents (Pl. XIV, figs. 17, 18). It is, therefore, concluded that the smaller of the two sporangia must be looked upon as an antheridium, while the larger functions as an oogonium. After fusion the oogonium may be found containing two nuclei in close association (Pl. XIV, fig. 19; Pl. XV, fig. 1). These two nuclei later fuse and the fusion stimulates the formation of a thick wall around the oospore (Pl. XV, fig. 2). The nucleus now divides by successive mitotic divisions forming a large zoosporangium enclosed within a thick cell wall. During these divisions a considerable quantity of chromatin becomes extruded into the cytoplasm, and this, together with the thick sporangium wall, renders it very difficult to observe the finer details. It is possible that some of the divisions are amitotic, though this cannot be said with any certainty; if there is true mitosis, it is very irregular and is effected with considerable chromatin discharge (Pl. XIV, fig. 19; Pl. XV, fig. 14).

When the zoosporangium has reached maturity the cytoplasm becomes vacuolated (Pl. XV, fig. 3), and the whole structure becomes cut up into a large number of uninucleated zoospores (Pl. XV, fig. 5). The size of the mature zoosporangium varies very considerably but it frequently causes hypertrophy of the cells of the host immediately associated with it. This hypertrophy, however, is not sufficient to cause any external deformation of the roots, and there is nothing in the appearance of the

roots of the host to indicate the presence of the fungus within the cells. A mature zoosporangium (Pl. XV, fig. 4) once was found within an epidermal cell which had given rise to a root hair through which the fungus had presumably obtained entry. The root hair was still apparently functional although there was a large zoosporangium in the basal part sufficient to cause the epidermal cell to swell up considerably.

It is considered probable, although it was impossible to make out the details, that during the formation of zoospores a meiosis occurs, reducing the chromosome number to half that present after the fusion in the oogonium.

At one time it was thought probable that these large thick-walled zoosporangia were winter ones, designed to carry the fungus safely over unfavourable conditions. This is not so, because they may be found throughout the year, always as a result of a fusion of two uninucleated sporangia within the same cell. Moreover, it seems probable that where two sporangia occur in the same cell these invariably function as sex organs. The reason for this is not clear, but it may be due, at least in part, to lack of nutrition available for the two developing individuals.

Frequently, however, only a single sporangium is present in a particular host cell; no fusion is possible and it continues to develop without any sexual act. The nucleus divides, first into two (Pl. XIV, figs. 7, 8), and then into a large number of nuclei (Pl. XIV, figs. 12, 13). In this way the whole structure becomes converted into a zoosporangium. The wall, unlike that of the zoosporangium formed as a result of a nuclear fusion, remains thin throughout its life. The size of the zoosporangium formed in this way is approximately that of the thick-walled type.

In the mature thin-walled zoosporangium, zoospores are formed in the same way as in the thick-walled one, by vacuolation of the cytoplasm (Pl. XIV, fig. 14). After the formation of the zoospores one or more small exit tubes are sometimes formed. These are not like the long coiled tubes found in *Olpidium Brassicae* but simple structures most closely resembling those of *O. Viciae*, often little more than swellings on the wall of the zoosporangium, which project to, or sometimes into, the cell wall of the host (Pl. XV, figs. 6–11).

The zoospores produced from the thin-walled zoosporangia are apparently exactly similar to those formed in the thick-walled ones, but, since apparently no nuclear fusion has occurred, the structures from which they have been formed are haploid, and therefore presumably there is no reduction division.

It is unfortunate that stages in the nuclear divisions of the mature sporangia are so unsatisfactory, and that where mitosis

has been observed, the details are so difficult to interpret. In consequence of this it is impossible to bring forward any evidence of the presence or absence of a reduction division. It has been observed, however, that the mitoses in the formation of the zoospores in the zoosporangia are very much smaller than those in the early stages of sporangia formation. This may be due in part to the quantity of chromatin which is being, or already has been, extruded into the cytoplasm.

It follows that, if there has been a fusion of the zoospores after they have entered the host cell, they were haploid in their previous free-swimming condition and unless there is sometimes a fusion of zoospores outside the host, those which give rise to the thin-walled zoosporangia must be haploid. No evidence has been obtained that these at any stage in their development become diploid and it is therefore concluded that there is no reduction division during the formation of zoospores within these zoosporangia. If this is so, there are two distinct types of zoosporangia, the one thick-walled, in which the nuclei undergo a meiosis; the other thin-walled in which all the divisions of the nuclei are mitotic.

The zoospores either may germinate within the original cell of the host or they may be liberated to the exterior. If no provision is made for their liberation they remain for a time within the original host cell in which the zoosporangium had developed, and it is possible to see them in large numbers swimming about for a considerable time. They finally penetrate the wall of the host cell and enter cells immediately surrounding that in which they developed. Both during the time they are in the parent host cell, and after they have entered a fresh one, the zoospores increase considerably in size so that it is difficult to give their exact dimensions. Pl. XV, fig. 12 shows one of these zoospores after it has emerged from the zoosporangium but is still enclosed in the same host cell. It will be seen that this zoospore is very much larger than that figured in Pl. XIV, fig. 2, which represents one which had passed out of the host tissues into the water film around the roots.

During the growth of the zoosporangia, whether they are thin- or thick-walled, considerable quantities of oil are present in the cytoplasm as droplets which vary very much in size. In the young sporangia (Pl. XV, fig. 14), there is frequently a single large globule; in the older sporangia there may be a number of large drops and also a considerable number of small ones (Pl. XV, fig. 15). This oil is doubtless a reserve food product which is used up by the young zoospores, as they frequently may be found associated with oil drops during the demarcation of their walls.

Considerable difficulty has been experienced in making out the method of discharge of the zoospores from the zoosporangia. The thin-walled type does not seem to have any special mechanism for the liberation of its contents; the whole zoosporangium simply splits and the zoospores in this way can make their way to the exterior. In the thick-walled ones, however, exit tubes are sometimes formed. Pl. XV, fig. 10 shows one which definitely passes into the adjacent cell and permits the zoospores to pass directly out of one parent host cell into another. This, however, is the only case in which the exit tubes were observed to pass through the wall of the host cell, all the others merely liberated the zoospores into the same host cell in which the parent zoosporangium was lying (Pl. XV, figs. 6–9). Pl. XV, fig. 11 is an example of one in which the exit tube has passed to the wall of the host cell but has not completely penetrated it. So far as could be observed it seems that the length of the exit tubes is limited, and that should the zoosporangium be lying close up against the wall of the cell there is more likelihood of the exit tube penetrating it, than if there is an appreciable gap between. The exit tubes were never found longer than those shown in Pl. XV, fig. 8.

As far as was possible an attempt was made to study the structure and method of division of the nucleus, using chiefly those sporangia in which the wall had not become thickened, and in which only slight chromatin discharge had occurred.

The resting nucleus is fairly large (Pl. XIV, fig. 5); it consists of a nuclear membrane surrounding a ring of chromatin, densest at the periphery and spreading out into a thinner zone towards the centre. In the middle is the karyosome, usually spherical in outline and homogeneous. Separating this structure from the chromatin is a nuclear vacuole. The structure of the resting nucleus is by no means constant, sometimes (Pl. XIV, fig. 6) there appear to be two central bodies. The larger one is more or less crescent shaped, the smaller one more or less oval, and there is scarcely any chromatin around the nuclear membrane. It seems probable that this is an extrusion stage in which the outlying chromatin becomes aggregated into a single mass and that the rest, presumably the whole of the karyosome, is extruded from the residual mass of chromatin and a fresh karyosome is later constituted. Such stages appear throughout the whole growth of the zoosporangia, though they can be more clearly seen in young ones. A single nucleus was observed in which three separate granules of chromatin were present in the centre of the nucleus, embedded in a mass of less dense nucleoplasm. This stage probably represents an intermediate condition in chromatin discharge before the whole of it has been collected

up into the two masses within the nuclear membrane (Pl. XIV, fig. 11).

As has been already mentioned stages in nuclear division were very rare. Pl. XIV, fig. 9 shows a typical metaphase. The nuclear membrane has disappeared, the spindle is typical though slightly elongated, and the chromosomes can be distinctly seen. It is interesting to note that the two nuclei are approximately in the same stage of division. Since this was in a young sporangium very little extruded chromatin was present. Pl. XIV, fig. 10 shows a telophase in which the chromosomes have become aggregated at the poles of the spindle which is itself becoming less clearly visible. In this zoosporangium there is a considerable difference in the distance apart of the chromatin masses in the dividing nuclei. The one in which they are furthest separated is probably the most typical.

In the later divisions the spindle becomes much more drawn out and the chromatin becomes irregularly dotted about on the spindle fibres, so that it is difficult to decide whether the nucleus is in the metaphase or anaphase of a division. The presence of granules of chromatin in the cytoplasm further complicates observations.

Discussion.

Of the species of the genus *Olpidium* which show a method of sexual reproduction in any way similar to what has been described above, *O. Viciae* is most closely allied to the present one. Kusano (22) has shown that there the resting sporangia are formed from zygotes produced by the fusion of two zoospores, while the uncopulated zoospores give rise to zoosporangia. The conclusion which we have come to concerning *O. radicale* is similar, in that the zoosporangia are formed directly from zoospores without conjugation. The resting sporangia, however, instead of being initiated by a copulation of gametes outside the host, are formed by their fusion within the host cells.

The zoospores of *O. radicale* are slightly longer than those of *O. Viciae*, being from 7–10 μ, though their breadth is slightly less. Both are uniflagellate and in both the flagellum is posterior. Unfortunately in *O. radicale* little opportunity has been found of studying these zoospores alive. The process of infection is the same in the two species and agrees closely with what has been described by Butler (4), Zopf (32) and others who have studied other members of the genus.

Kusano found that *O. Viciae* did not cause any hypertrophy of the host tissues until the disease had become well established; then small pustules were formed, and all the epidermal cells of the spot, both infected and intact, became much enlarged and

swollen. Moreover, this species was found on the stem and leaves of the host plant. In *O. radicale* only the cortical cells of the root become attacked and no hypertrophy is caused to any of the cells.

The early stages in *O. Viciae* are the same whether the fungus soma is a zygote or an unconjugated zoospore; similarly we found that in the early stages there was no observable difference between those zoospores which were destined to fuse and form the resting sporangia, and those which would later develop directly into zoosporangia.

The development of the zoosporangium in both species is very similar; in both the size is very variable, depending largely upon the area of the host cell in which it is growing, though frequently the mature zoosporangium fails to fill the whole cell. This may be due to insufficient food supplies available for the fungus. The further development of the zoosporangium differs in detail from that described in *O. Viciae*. The wall in *O. radicale* remains more or less thin throughout life and in consequence no exit tubes are formed. We are of the same opinion as Kusano that the expulsion of the zoospores is by osmotic pressure, and in these zoosporangia it appears that the thin walls are simply broken down by the pressure developed inside, and no special mechanism is necessary for the liberation of their contents.

The resting sporangia in *O. Viciae* are similar in appearance to those of *O. radicale*. At maturity the wall appears to consist of a thick outer, and a thin inner membrane; Kusano found in his species that the inner wall was thicker than the outer, a point in which it differs from *O. radicale*; moreover, the outer wall was yellow and not colourless.

We have found the resting sporangia both singly and also in groups together in the same cell, as in *O. Viciae*. Kusano found these resting sporangia commonly throughout the year, but he observed that the relative number of resting sporangia to zoosporangia varied at definite periods. In *O. radicale* the variation was not the same, being more definitely marked in different roots than at different times of the year. Kusano noticed the presence of oil drops in the resting sporangia; we have observed the same, though the globules tended to decrease in size just prior to the formation of zoospores.

In *O. radicale* exit tubes are formed, which very much resemble those found in *O. Viciae*. In both they are short and, although the point is not very clearly brought out in *O. Viciae*, in both, the exit tubes frequently fail to penetrate the wall of the host.

O. radicale in some respects may be compared with the genus *Olpidiopsis*. Barrett (2) has described the formation of sex

organs, and found that in *Olpidiopsis vexans* the character of these varied with the conditions of culture. A definite mycelium is present from which the sex organs are formed; there is a large oogonium, with a smaller associated antheridium. The wall between the antheridium and the oogonium breaks down and subsequently the contents of the antheridium pass into the oogonium and a nuclear fusion follows; Barrett does not explain from what these sex organs are produced. The walls of the resting sporangia, which are to form the zygote, differ considerably in thickness and spiny appearance from what we have found in *Olpidium radicale*. The exit tubes are formed in the zoosporangia, but they are apparently not present in the resting sporangia. In *O. radicale* the exit tubes are found on the resting sporangia but not on the zoosporangia.

In its morphology, *O. radicale* seems to be intermediate between the genus *Olpidium* as exemplified by *O. Viciae* and *Olpidiopsis*, as shown by *Olpidiopsis vexans*. It agrees with *Olpidium Viciae* in all points with the exception of the formation of sex organs within the host tissues; in this respect it may be compared with *Olpidiopsis vexans*.

Němec (25) has recently shown that conjugation of zoospores, similar to what Kusano has described in *Olpidium Viciae*, occurs in *O. Brassicae*; he had previously observed binucleated sporangia in *O. Salicorniae* (23) which he thought had been formed by the conjugation of two cells.

Butler (4) has figured and described a number of species of *Olpidiopsis* and *Pseudolpidium*. In the latter genus definite hyphae are present, and the sporangia are formed intercalary or more rarely terminally.

Exit tubes are absent from the zoosporangia of *Eurychasma Dicksonii* which was described by Magnus in the cells of *Ectocarpus*.

Asterocystis radicis (20, 26, 31) differs from *Olpidium* and *Olpidiopsis* in the absence of any tube for the escape of the zoospores, and in the stellate appearance of the resting sporangia. In the former feature it agrees with *Olpidium radicale*. Both are dependent to some extent upon the breakdown of the host tissues for the liberation of the zoospores and both have been found in species of *Veronica*.

Certain other genera show distinct similarities to the species we have described. Griggs (18) has shown in *Monochytrium Stevensianum*, occurring in the stem and leaves of *Ambrosia artemisifolia*, that the zoospores, after entering the host cells, fuse in pairs. Their further fate is unknown. In this form those zoospores which fail to conjugate become coenocytic and segment to form a number of zoosporangia. Although the stages

in the development of the zoosporangia are quite unlike those in *Olpidium radicale* yet in the copulation of isogametes within the host cells the species agree very closely. Griggs never found these resting sporangia developed beyond a binucleate condition, but it seems probable that they would have finally become multinucleated and developed very much as do those of *O. radicale.*

Atkinson (1) has pointed out that Griggs's *Monochytrium* closely resembles the genus *Reesia. Reesia amoeboides* described by Fisch (11) has been included by Fischer (12) in the genus *Olpidium,* so that there seems some evidence that *Monochytrium Stevensianum* should also be placed in that genus.

In 1912 Griggs described the development and cytology of a species of *Rhodochytrium.* Here both resting spores and large resting zoosporangia are formed. These later give rise to zoospores with two flagella, and therefore it is impossible to relate this genus with *Olpidium.* In the presence of both thick-walled resting spores and thin-walled zoosporangia *Rhodochytrium* agrees with what we have described in *Olpidium radicale.*

It is when one turns to the cytology that the relationship of *O. radicale* becomes more apparent. The sporangia formed prior to the fusion within the host cell are invariably uninucleated; they fuse to form a resting sporangium containing subsequently a fusion nucleus which at once divides up to form a large number of nuclei. In this respect it differs from what Barrett described in *Olpidiopsis,* where both the oogonium and antheridium are multinucleated, but agrees with *Olpidium Viciae* where the zygote nucleus formed by the copulation of isogametes divides up to form a multinucleated resting sporangium as soon as it has entered the host cell.

Griggs (18) came to the conclusion that the nuclear divisions in *Monochytrium Stevensianum* were amitotic. We did not find this in *O. radicicola,* though often chromatin extrusion occurs, yet in one or two instances definite mitoses have been observed proving that, at least during part of the life-cycle the nuclear divisions are mitotic. Kusano also found in *Olpidium Viciae* that mitosis occurred and observed that considerable chromatin extrusion took place.

Discharge of chromatin from the nucleus during the formation of zoosporangia frequently occurs in the Synchytriaceae. Curtis (9), Griggs (16, 17), Kusano (21), Rosen (28) and Stevens (29) have observed it in the formation of the prosorus of species of *Synchytrium.* Since *Olpidium* and *Synchytrium* are fairly closely allied it is not surprising to find a similarity.

Kusano (22) figures mitotic stages in *Olpidium Viciae* which

are quite comparable with our figures, though doubt would be felt in ascribing some of the stages in the nuclear divisions in the zoosporangia, figured in his paper, as definite evidence of a mitosis. Similar stages have, however, been observed in *O. radicale* which strengthens the idea of the close affinity of the two species.

It is suggested that a series may be traced from *O. Brassicae* and *O. Viciae* in which the zoospores conjugate outside the host cells, through *O. radicale* in which the copulation is delayed until the zoospores have entered the host, to the condition in *Olpidiopsis vexans* in which the zoospores have become multinucleated before fusion occurs. It seems, therefore, that the chief difference between *Olpidium* and *Olpidiopsis* is one of degree, and that *Olpidium radicale* supplies a link in an evolutionary series from the simple condition in *O. Brassicae* to the more complex state found in species of the genus *Olpidiopsis*.

The size and development of exit tubes, which are found well developed both in *Olpidium Brassicae* and also in *Olpidiopsis vexans*, are probably more or less directly influenced by the conditions under which the fungus is living, and do not indicate an evolutionary series.

From a general consideration, taking into account that the conjugants are uninucleate at the time of copulation, our fungus appears to be more closely related to the genus *Olpidium* than to the genus *Olpidiopsis*, and we, therefore, refer it to the former genus as a new species with the following diagnosis:

Diagnosis.

Olpidium radicale sp. nov.

Sporangia in cellulis corticis radicum inveniuntur, vel singulatim vel plura in unum collecta, globosa vel oblonga, circ. 60–200 μ diam. Zoospori hyalini, immaturi triangulares, maturi globosi, cum uno flagello posteriore. Sporangia perdurantia vel singulatim vel plura in una cellula, formis variis, circ. 100–160 μ diam., orta e copulatis gametibus. Murus exterior spissus et levis, interior tenuis. Haec sporangia germinata zoosporis faciunt qui per unam vel raro per duas tubas evadunt.

Hab. In radicibus plantarum palustrium, *Veronicae Beccabungae, Lepidii sativi*, specierum graminum. Vere et aestate. Dunton Green, Kent, England.

The microscopic apparatus used in this investigation was obtained through a grant from the Dixon Fund of the University of London.

SUMMARY.

1. A new species of the genus *Olpidium*—*Olpidium radicale*—is described.

2. The zoospores enter the epidermal cells of the root by means of a germ tube, and may again become active within the host cells. Finally they come to rest, round up and form a sporangium.

3. Usually if two are present in the same host cell they migrate towards one another, and the contents of the smaller one pass into the larger, and the nuclei fuse. During this process a considerable quantity of chromatin is extruded into the cytoplasm. The wall becomes thickened, and concurrently with the growth of the zoosporangium which is accompanied by nuclear division, it is seen to be composed of a thick outer and a thin inner coat.

4. If no fusion occurs the sporangium grows and nuclear division takes place, resulting in the formation of a zoosporangium which differs from that produced sexually in having a thin wall.

5. When mature both kinds of zoosporangia divide up to form uninucleated zoospores which remain for some time enclosed within the zoosporangia.

6. The zoospores are liberated from the thin-walled zoosporangia by the bursting of the wall. They are set free from the thick-walled ones by short exit tubes, which rarely penetrate the wall of the host cell.

7. These zoospores may either make their way to the exterior or they may pass into another adjacent host cell, and after enlarging form fresh sporangia. The size of the zoospore may increase considerably while still motile.

8. The method of nuclear division is always mitotic, though in some of the later divisions considerable amounts of chromatin are extruded into the cytoplasm, and the mitotic figures become less regular. The presence of this chromatin and reserve oil globules render it difficult to study the later divisions of the nuclei in the zoosporangia in detail.

9. The systematic position of the fungus is discussed and reasons are given for considering it to be a new species. Its relation to both the genera *Olpidium* and *Olpidiopsis* is considered.

REFERENCES.

(1) ATKINSON, G. F. A new genus of Chytrids. Bot. Gaz. XLIX (1910), 311–312.

(2) BARRETT, J. T. Development and Sexuality of some species of *Olpidiopsis* (Cornu) Fischer. Ann. Bot. XXVI (1912), 209–238, Pls. 23–26.

(3) BRAUN, A. Über *Chytridium*, eine Gattung einzelliger Schmarotzergewächse auf Algen und Infusorien. Abh. Köngl. Akad. d. Wiss. zu Berlin (1855), 21–84, Pls. 1–5.

(4) Butler, E. J. An account of the genus *Pythium* and some Chytridiaceae. Mem. Dept. Agric. India, I (1907), No. 5, 1–160, Pls. 1–10.
(5) de Bary, A. and Woronin, M. Beitrag zur Kenntnis der Chytridineen. Berichte d. naturf. Ges. Freiburg, III (1865), H. 2, 22–61.
(6) Chatton, E. and Brodsky, A. Le parasitisme d'une Chytridinée du genre *Sphaerita* Dangeard chez *Amoeba limax* Dulard. Étude comparative. Arch. f. Protist. XVII (1909), 1–18, Figs. 1–6.
(7) Cook, W. R. Ivimey. The genus *Ligniera* Maire and Tison. Trans. Brit. Mycol. Soc. XI (1926), 196–213, Pls. 8–9.
(8) —— The methods of nuclear division in the Plasmodiophorales. Ann. Bot. XLI (1928), 347–377. Pls. 5–6.
(9) Curtis, K. M. The life-history and cytology of *Synchytrium endobioticum* (Schlb.) Pers., the cause of Wart Disease of Potato. Phil. Trans. Roy. Soc. 210, B (1921), 409–478, Pls. 12–16.
(10) Dangeard, P. A. Recherches sur les organismes inférieurs. Ann. Sci. Nat. Sér. 7, IV (1886), 241–341, Pls. 11–14.
(11) Fisch, C. Beiträge zur Kenntnis der Chytridiaceae. Erlangen, 1884.
(12) Fischer, A. Untersuchungen über die Parasiten der Saprolegnieen. Jahrb. f. Wiss. Bot. XIII (1882), 286–371, Pls. 13–15.
(13) —— Phycomycetes. Rabenhorst's Kryptogamenflora, I Bd., IV Abt. 1892.
(14) Fron, G. and Gaillat, Mlle. Sur la maladie de brûlure des racines de Graminées. Comptes Rendus Acad. d'Agric. de France, IX (1925), 119–122.
(15) Gäumann, E. Vergleichende Morphologie der Pilze. 1926.
(16) Griggs, R. F. Some aspects of amitosis in *Synchytrium*. Bot. Gaz. XLVII (1909), 127–138, Pls. 3–4.
(17) —— Mitosis in *Synchytrium*. Bot. Gaz. XLVIII (1909), 339–358, Pls. 16–18.
(18) —— *Monochytrium*, a new genus of the Chytridiales. Ohio Nat. X (1910), 44–54, Pls. 3–4.
(19) —— The development and cytology of *Rhodochytrium*. Bot. Gaz. LIII (1912), 127–173, Pls. 11–16.
(20) Guyot, A. L. Contribution à l'étude systématique et biologique de l'*Asterocystis radicis*. Ann. des Epiphyties XIII (1927), 79–93, Figs. 1–12.
(21) Kusano, S. A contribution to the cytology of *Synchytrium* and its hosts. Bull. Coll. Agric. Tokyo Imp. Univ. VIII (1909), 79–147, Pls. 8–11.
(22) —— On the life-history and cytology of a new species of *Olpidium*, with special reference to the copulation of motile isogametes. Journ. Coll. Agric. Tokyo Imp. Univ. IV (1912), 142–199, Pls. 15–17, Fig. 1.
(23) Němec, B. Zur Kenntnis der niederen Pilze. III. *Olpidium Salicorniae* n. sp. Bull. Internat. Acad. Sci. Bohême, XVI (1911), 136–144, Pl. 1, Figs. 1–26.
(24) —— Zur Kenntnis der niederen Pilze. IV. *Olpidium Brassicae* und zwei *Entophlyctis*-Arten. Bull. Internat. Acad. Sci. Bohême, XVII (1912), 16–25, Pls. 1–2, Fig. 1.
(25) —— O pohlavnosti u *Olpidium brassicae*. Zolastni otisk ze Sborniku Klubu, Praze, 1920, pp. 1–3. 1922.
(26) Pascher, A. *Asterocystis* de Wildeman und *Asterocystis* Gobi. Beih. Bot. Centrlbl. XXXV (1917), 578–9.
(27) Petersen, H. E. An account of Danish Freshwater Phycomycetes, with biological and systematic remarks. Ann. Mycol. VIII (1910), 494–560, Figs. 1–27.
(28) Rosen, F. Ein Beitrag zur Kenntnis der Chytridiaceen. Cohn Beit. z. Biol. d. Pflanzen, IV (1887), 253–269, Pls. 13–14.
(29) Stevens, F. L. and Stevens, A. C. Mitosis of the primary nucleus in *Synchytrium decipiens*. Bot. Gaz. XXXV (1903), 405–415, Pls. 16–17.
(30) Woronin, M. *Plasmodiophora Brassicae*, Urheber der Kohlpflanzen-Hernie. Jahrb. f. Wiss. Bot. XI (1878), 548–574, Pls. 29–34.
(31) de Wildeman. Notes Mycologiques. Ann. de la Soc. Belge de Microscopie, XVII (1893), 5–32, Pls. 1–3.
(32) Zopf, W. Zur Kenntnis der Phycomyceten. I. Zur Morphologie und Biologie der Ancylisteen und Chytridiaceen. Nova Acta d. K. Leop.-Carol. Deut. Akad. d. Naturf. XLVII (1884), 143–236, Pls. 12–21.

EXPLANATION OF PLATES XIII–XV.

The photomicrographs were made with a Zeiss Seidentopf Photographic Eyepiece at tube length 115 mm. using a Zeiss 2 mm. (n.a. 1·4) objective (Pl. XIII, figs. 1, 3–10, 12–15) and Zeiss 4·2 mm. (n.a. 0·65) objective (Figs. 2, 11).

The drawings were made with a camera lucida at table level with tube length 160 mm. using a Zeiss 2 mm. (n.a. 1·4) objective and compensating ocular ×20 (Pl. XIV, fig. 2; Pl. XV, fig. 12), compensating ocular ×15 (Pl. XIV, figs. 3–13, 15, 16, 18, 19; Pl. XV, figs. 1, 2, 5, 13–15) and compensating ocular ×10 (Pl. XIV, figs. 1, 14, 17; Pl. XV, figs. 3, 4, 6–11).

PLATE XIII.

Fig. 1. A young zoospore inside a root hair. The nucleus is visible lying more or less in the middle. ×550.

Fig. 2. A general photograph showing a number of young zoospores within the host tissues. ×250.

Fig. 3. A uninucleated sporangium, which will later form a zoosporangium. ×550.

Fig. 4. A later stage in the development of a zoosporangium, before it becomes divided up into zoospores. ×550.

Fig. 5. Zoospore formation in a zoosporangium. ×550.

Fig. 6. Two zoospores in the process of conjugation; these are smaller than are usually found. ×550.

Fig. 7. Two larger zoospores lying in the same cell which will shortly associate and fuse. ×550.

Fig. 8. A stage in fusion showing the contents of one zoospore already passed into the other which now contains two nuclei. ×550.

Fig. 9. Another stage in fusion in which the contents of one zoospore is passing into the other; the two nuclei are still in their own cells. ×550.

Fig. 10. A uninucleated resting sporangium, showing the thick wall which has formed after the fusion of the nuclei. ×550.

Fig. 11. A general view of the thick-walled resting sporangia in the host cells. ×250.

Fig. 12. Two thick-walled resting sporangia in the same cell, showing the formation of zoospores. The exit tube cannot be made out in the photograph. ×550.

Fig. 13. A mass of young zoospores which have just become liberated from a sporangium, showing their appearance before they start to grow. ×550.

Fig. 14. A mass of zoospores which have failed to reach the exterior and have continued to develop within the host cell. ×550.

Fig. 15. A photograph showing the association of the zoospore with the nucleus of the host cell; the latter is visible on the left of the zoospore and has already become distorted. ×550.

PLATE XIV.

Fig. 1. Sketch showing two zoospores lying in a root hair; they have already settled down and have withdrawn their flagella. The nuclei are simple but the slide not being stained made it difficult to make out the karyosome. ×1700.

Fig. 2. Single zoospore, showing the flagellum and general structure of the nucleus at this stage. This is the characteristic shape and size of the free-swimming zoospores. ×3400.

Fig. 3. Zoospore after coming to rest within the cell of the root; the cytoplasm has already become vacuolated and the nucleus is becoming differentiated into chromatin and karyosome. ×2700.

Fig. 4. A later stage in the development of the zoospore; the nucleus has become active and chromatin is already being discharged from it. ×2700.

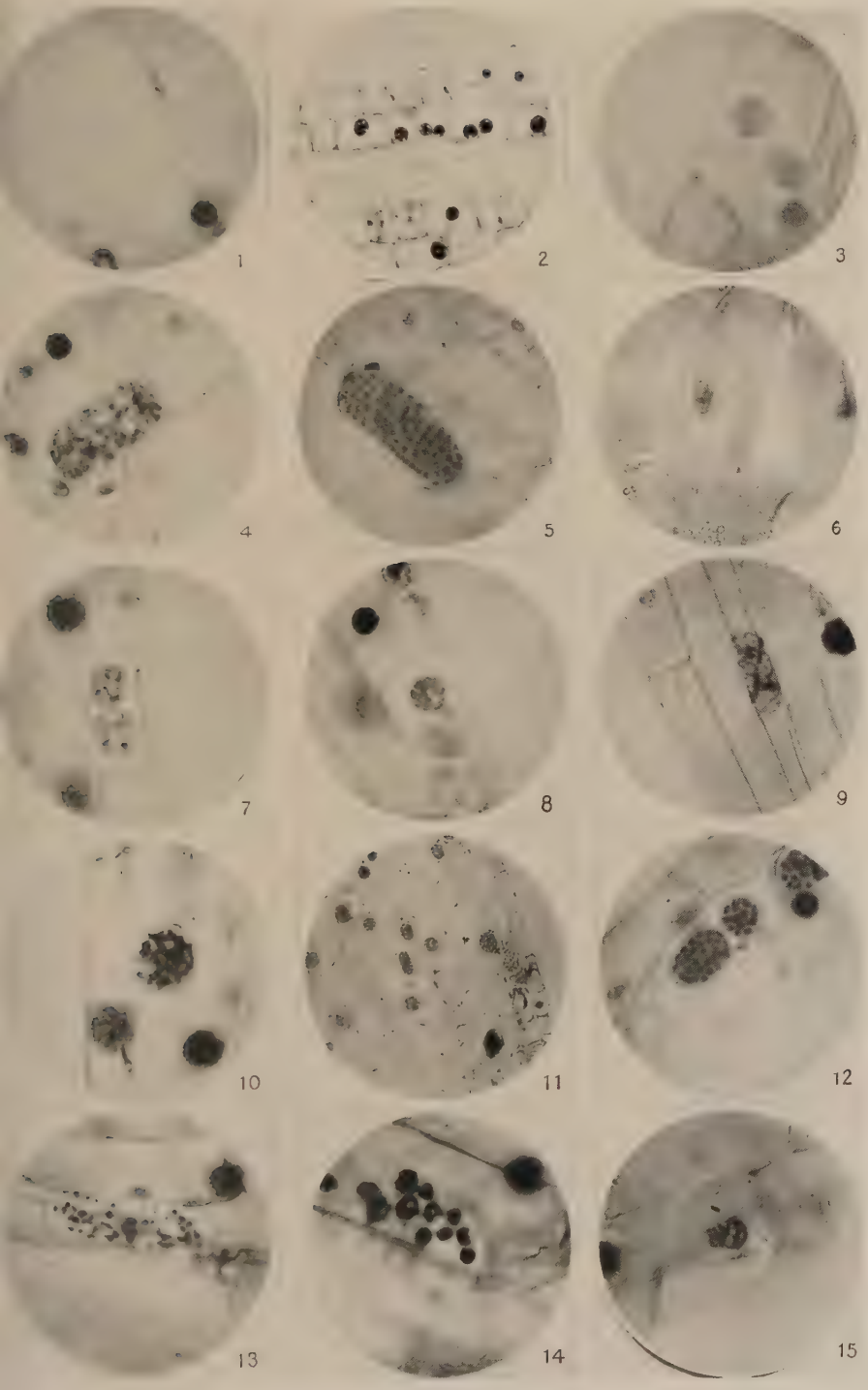
Fig. 5. A still later stage in the development of the zoospore; granules of chromatin are to be seen lying in the cytoplasm together with a well-developed karyosome. ×2700.

Fig. 6. A uninucleated sporangium in which the nucleus is seen in a state of chromatin discharge. The karyosome has divided into two and part of this will later be discharged from the nucleus. ×2700.

Fig. 7. A sporangium in which the nucleus has just divided and the daughter nuclei are seen with the nuclear membrane already re-formed. Extruded chromatin is to be seen between the two nuclei. ×2700.
Fig. 8. A sporangium in which the nucleus has completely divided into two and in which very little chromatin has been extruded. ×2700.
Fig. 9. A sporangium in which the two nuclei are in process of division. The chromosomes are arranged on the metaphase plate, the spindle is well defined but true asters are absent. Granules of chromatin are to be seen in the cytoplasm. ×2700.
Fig. 10. A sporangium in which the nuclei are in division; three are shown in the telophase. Masses of chromatin are lying in the cytoplasm. ×2700.
Fig. 11. A sporangium with three nuclei, showing the breaking up of the karyosome prior to a further extrusion of chromatin. One shows the karyosome with three masses of chromatin, one with two and the third in a resting condition. ×2700.
Fig. 12. A sporangium in which there has been no fusion and the original nucleus has divided up into four which are to be seen in a resting condition. ×2700.
Fig. 13. A large multinucleated sporangium with a thin wall, formed directly from a single zoospore. The nuclei are in a resting condition. ×2700.
Fig. 14. A thin-walled zoosporangium, showing the zoospores each with a single nucleus and oil globule, just prior to bursting. ×1700.
Fig. 15. Two zoospores about to conjugate, showing the still slightly pointed posterior ends. ×2700.
Fig. 16. A later stage in which the two conjugants show a distinct difference in size, and in which the larger is becoming vacuolated. The nucleus of the smaller one is beginning to migrate into the larger. ×2700.
Fig. 17. A later stage in which the contents of the smaller gamete have passed into the larger and the two nuclei are just about to fuse. ×1700.
Fig. 18. A slightly later stage in which the nuclei are about to fuse. The wall of the zoosporangium is already beginning to thicken. ×2700.
Fig. 19. A zygote in which the nuclei are in process of fusion. The two conjugating nuclei both discharge a considerable quantity of chromatin during the process, which is visible in the cytoplasm. ×2700.

PLATE XV.

Fig. 1. Another zygote with the nuclei about to fuse, showing the extruded chromatin in the cytoplasm and the slightly thickened wall. ×2700.
Fig. 2. The fusion nucleus showing the thick chromatin band around the nucleus and the well-marked karyosome in the centre; the extruded chromatin is visible in the cytoplasm. ×2700.
Fig. 3. A multinucleated zoosporangium, showing the formation of a mass of nuclei within the much enlarged thick-walled sporangium. ×1700.
Fig. 4. A large resting sporangium lying in the terminal part of a cell bearing a root hair. ×1700.
Fig. 5. A mature thick-walled zoosporangium containing zoospores which are approximately the same size as those of the thin-walled zoosporangium, Pl. XIV, fig. 14. ×2700.
Fig. 6. A mature zoosporangium showing an early formation of a single short exit tube. The contents of this zoosporangium are not shown in detail. ×1700.
Fig. 7. Another zoosporangium showing the development of a single exit tube forming at the end of the zoosporangium. ×1700.
Fig. 8. A drawing showing two small zoosporangia lying in a host cell each of which has formed a small exit tube. ×1700.
Fig. 9. A zoosporangium with the exit tube in surface view, showing the crinkling of the sporangium wall after the escape of the zoospores. ×1700.
Fig. 10. A single host cell with three zoosporangia; two have not formed any exit tubes, but the third has formed one which has penetrated through the wall of the cell. ×1700.



OLPIDIUM RADICALE SCHWARTZ & COOK

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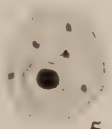
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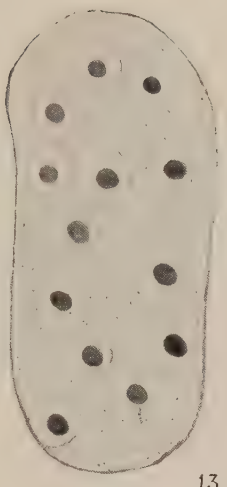
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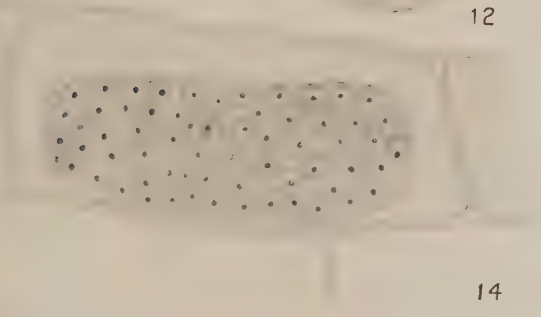
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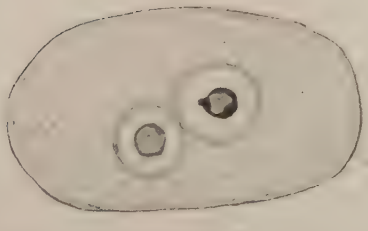
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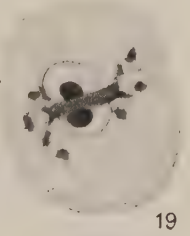
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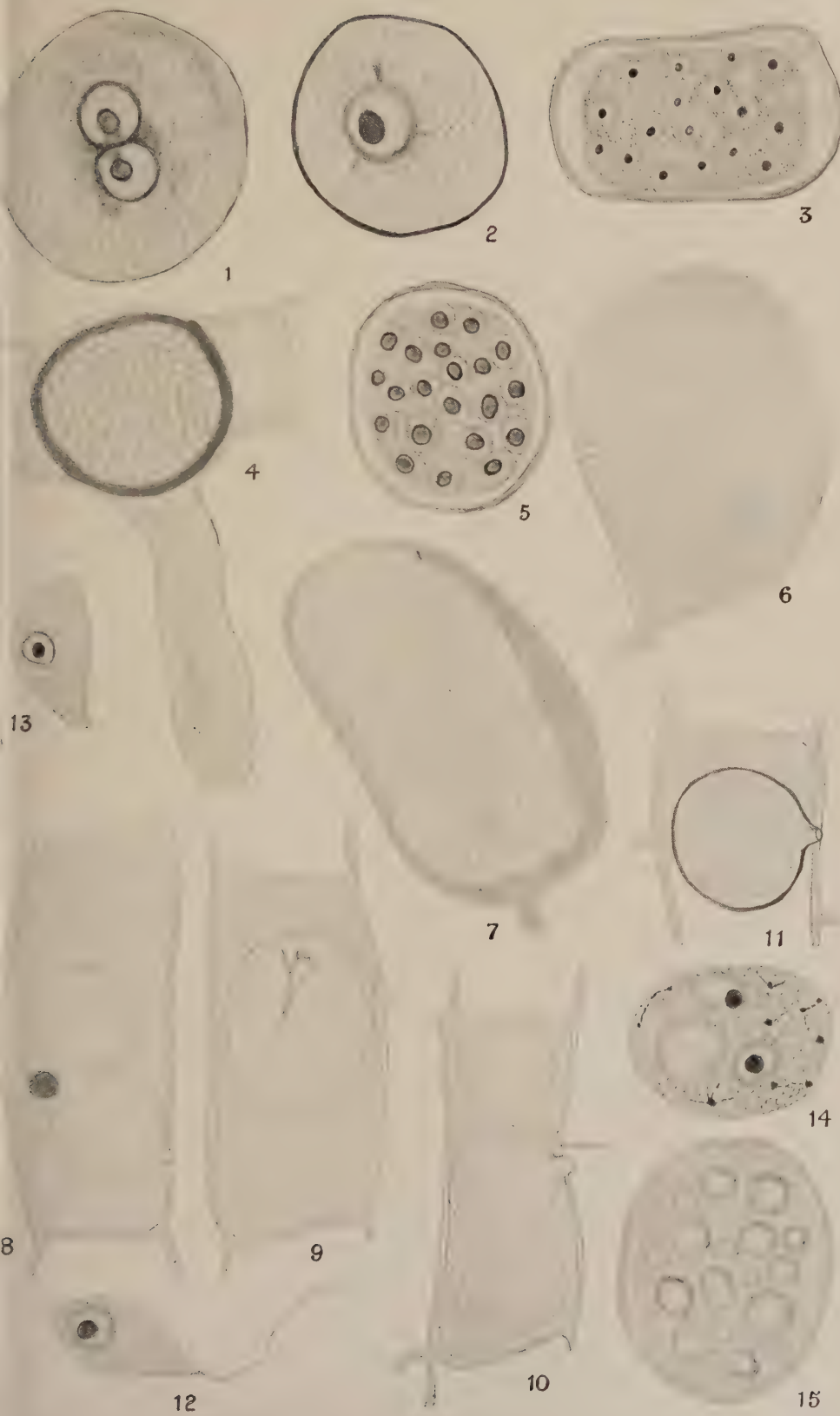
OLPIDIUM RADICALE SCHWARTZ & COOK



OLPIDIUM RADICALE SCHWARTZ & COOK

Fig. 11. Another zoosporangium in which the exit tube, although passing into the wall, has not completely penetrated it. ×1700.
Fig. 12. A zoospore lying in a cell of the host. This zoospore has developed within the host and has never passed to the exterior. Compare the size of this zoospore with that immediately after penetrating the host tissues. ×3400.
Fig. 13. A zoospore which has lost its flagellum and is about to become spherical. ×2700.
Fig. 14. A young sporangium showing the large oil globule which has already developed. ×2700.
Fig. 15. An older sporangium in which numerous oil globules have been formed; the nuclear structures have not been drawn. ×2700.

OLPIDIUM RADICICOLUM DE WILDEMAN AND THE "HYBRIDISATION NODULES" OF SWEDES.

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(With Plates XVI, XVII.)

The roots of certain cultivated cruciferous plants, particularly swede, turnip and cabbage, are sometimes more or less irregularly swollen and distorted, or may bear tumour-like outgrowths or nodules of various shapes and sizes. These hypertrophies or abnormalities are frequently associated with evident and definite parasites, the most familiar being *Plasmodiophora Brassicae*, the cause of Finger-and-Toe disease, and the larval stage of a weevil (*Ceuthorhyncus sulcicollis* Gyll.). The presence of the particular parasite may usually be ascertained readily by a cut across the abnormal growth, confirmed, if necessary, by a microscopical examination.

Other malformations are, however, sometimes met with, which are often liable at first sight to be mistaken for Finger-and-Toe, but when their tissues are examined under the microscope no trace can be found of any parasitic organism. One rather striking feature sometimes shown by these excrescences is the production of colourless leafy shoots from the roots, often fairly deep down in the soil, a phenomenon which at different times has attracted the attention of several observers.

A note in *The Gardeners' Chronicle* (1872), p. 1066, accompanied by figures, records the exhibition before the Scientific Committee of the Royal Horticultural Society by Mr Wilson Saunders of a portion of a root of a brussels sprout bearing a quantity of blanched adventitious buds. The unusual situation of buds upon roots was commented upon, and the phenomenon

was attributed partly to the plants having been headed down too low.

Caspary published in 1873 an account, illustrated by a plate, of a rape bearing on the lower part of the swollen main root a large number of rounded "tubers," from several of which shoots had sprouted. A description is given of the microscopical structure of these "tubers," in which no trace of fungal hyphae or insect attack or other organism of external origin could be discovered. Caspary considers it probable that the "tubers" represent roots of the second or third orders. He refers also to the fact that Kühn (9), in a work which I have not seen, mentions the occurrence of similar outgrowths on the roots of kohlrabi, the cause of which he was unable to ascertain.

Subsequently, Caspary (3) describes how he took twelve of these "tubers" bearing leaf-buds, and planted them in a pot. Only one rooted and survived the winter, and in the following spring it was planted out in an open border, where it ripened seeds. It is not stated whether this plant bore any "tubers" upon its roots. A number of seedlings were raised from these seeds, and planted out in the open, where they produced large, well-grown plants. These were lifted out of the ground at the end of October, and all of the thirty-eight plants bore monstrous "tubers" upon their roots, and of these twenty-two bore, in addition, from one to thirty-nine leafy shoots springing from the "tubers." Hence, Caspary concludes that the peculiarity of forming "tubers" instead of ordinary roots had already become an innate property of the plant to such a degree that it was transmitted by heredity to the seedling.

In his classical paper on *Plasmodiophora Brassicae*, published in 1878, Woronin mentions the occurrence of leafy shoots from swellings, which were all ascribed to Finger-and-Toe, occurring not only on the roots of rape, but also on cabbage, and particularly strongly developed and abundant on kohlrabi. Since I have not met with the production of leafy shoots on the roots of Cruciferae attacked *only* by *P. Brassicae*, I think it extremely likely that Woronin sometimes mistook the nodules or "tubers" described by Caspary and referred to above for the somewhat similar deformities due to *P. Brassicae*. Woronin explains Caspary's results in obtaining roots bearing nodules from the sowing of seeds from infected plants as due to infection from the soil.

A very full account of the occurrence and structure of the nodules or "tubers" is given by Helweg in two papers, which appeared in 1910 and 1914 respectively. In the earlier paper Helweg records his own investigations of the hybrids of swedes and turnips and closely allied cultivated forms, and

states that he regards the presence of peculiar nodules or swellings upon the roots of these plants as an important characteristic mark of certain hybrids. Hence, he refers to these deformities as "hybridisation nodules." He reports that the nodules may exceptionally reach a diameter of 10 to 15 cm. and may entirely take the place of the root itself. Very commonly, a number of blanched adventitious shoots grow either from the nodules or between them.

Helweg contends that the tendency to form these nodules is an hereditary character depending upon the hybrid origin of the plant. Nevertheless, he admits that certain of his experiments carried out to support his contention are not conclusive. As a matter of fact, some of his results appear to establish the reverse, and, hence, he is obliged to assume that other factors, such as the nature of the soil, or the temperature, may determine the formation of nodules. He cites two instances in particular, in one of which, although the mother plants were without nodules, the offspring included a high percentage of noduled plants. In the other experiment, the mother plants with large nodules upon the roots produced descendants among which there were no plants with nodules.

Helweg's second paper (8) contains a short account of information obtained from researches undertaken by the Danish Experimental Organisation for Crops, on crosses between swedes and turnips, and the nodosities occurring on their roots. He begins by pointing out that swedes are derived from rape (*Brassica Napus*), and turnips from Rübsen (*B. campestris*), and that no nodosities occur on the roots of crosses between two *Napus* forms or two *campestris* forms, but they are found when a *Napus* form is crossed with a *campestris* form, whichever is the female parent. He then goes on to describe in detail the monstrous outgrowths (Kreuzungsknoten, *i.e.* nodosities due to crossing or "hybridisation nodules") which result from the crosses. These are of various forms according to whether the hybrid is rape-like, swede-like or turnip-like. Finally, he points out the characters by which the above deformities may be distinguished from those caused by Finger-and-Toe (*Plasmodiophora Brassicae*).

In the Revised Leaflet No. 77, "Finger and Toe Disease" (14), recently issued by the Ministry of Agriculture and Fisheries, a reference, accompanied by a figure, is made to the "hybridisation nodules" on swedes as apt to be mistaken for the growths due to Finger-and-Toe. The exact cause of their production is stated to be unknown, but that they are looked upon as definitely characteristic of certain supposed hybrids.

Swedes bearing nodules, agreeing with the descriptions and

figures referred to above, are often met with in fields and gardens in the neighbourhood of Newcastle-upon-Tyne, and are liable to be mistaken for cases of Finger-and-Toe. Hence, we have been accustomed at Armstrong College to describe the disease in question as "False Finger-and-Toe," a name which I believe was first applied to it by Professor M. C. Potter. In November 1924 a swede attacked by this disease was pulled up in a field and brought into the Botanical Laboratory. The soil was washed from the roots, and the swede was supported in the mouth of a glass jar containing water, with the lower portion of its roots immersed, so as to keep the plant fresh. The stem continued to grow and produced some fresh leaves, and numerous fine roots were put out from the neighbourhood of the nodules.

Up to this time I had seen no mention in print of these swellings, nor was I aware of the views expressed by Helweg as to their origin. In the course of his account of *Plasmodiophora Brassicae,* Woronin (19) reported the discovery of *Chytridium Brassicae* (*Olpidium Brassicae* (Wor.) Dang.) attacking seedling cabbage plants, and, after reading this account, the possibility occurred to me that the same parasite might be the cause of "False Finger-and-Toe." The probability, that in the course of his investigations, Woronin wrongly associated together some of the swellings and characteristics of these two distinct diseases has been referred to above, and this surmise helped to strengthen my suspicion that *Olpidium* might be present.

A careful microscopical examination of the nodules of the diseased swede was made, and, although I failed to discover any trace of a parasite in the nodules themselves, I found both the temporary and resting sporangia of an *Olpidium* present in abundance in the cells of the rootlets growing from the bases of the nodules.

During the two years since this discovery, a large number of swedes bearing similar nodules, obtained from various gardens and fields, have been examined, and in most the same species of *Olpidium* has been found in some of the finer roots. From this fact, as well as from infection experiments and other considerations, I am of opinion that this *Olpidium* is responsible for the so-called "hybridisation nodules" or "False Finger-and-Toe" of swedes, and presumably also of other similar outgrowths occurring sometimes on other cultivated cruciferous plants.

Description and Identification of the Parasite.

The parasite is found most abundantly in the piliferous layer, as well as in the outermost cells of the cortex, of the finer roots, particularly in those which spring from the neighbourhood of the nodules. It is also sometimes present in the root hairs

(Pl. XVII, figs. 8, 10). The smallest and youngest parasites were seen a short distance behind the tip of the root, and none were found in the cells of the apical meristem or in its neighbourhood. In seedling Crucifers the cells of the "collar," at the junction of the stem and root, often contained large numbers of the sporangia, and as a result of the infection the "collar" was sometimes brownish. In water cultures of mature swedes the infected roots could often be recognised by the darker and more watery appearance of the root apex, although for a time at least, the rest of the root retained its normal colour and appearance. Later, many of the infected roots turned brown and died.

Both temporary and resting sporangia were found in most of the roots examined. The former vary considerably in shape and size, as well as in the number contained in one cell. When a cell contains several temporary sporangia, and as many as sixteen have been counted in one cell (Pl. XVII, fig. 5), each is usually more or less spherical in form, but is liable to deformation by mutual pressure. The average diameter of a temporary sporangium is 20 to 25μ, but it may reach 45μ. A cell containing only a single temporary sporangium (Pl. XVII, figs. 5, 6) is often completely filled, and frequently the sporangium has a more or less cylindrical or worm-like form; it may reach a huge size—as great as 220μ × 25μ—and contain a very large number of spores. Sporangia of a more or less indefinite form are often met with (Pl. XVII, fig. 9). The temporary sporangium is colourless and thin-walled, and is furnished with from one to three emptying tubes, which are usually rather short and mostly measure from 5 to 10μ in length and about 5μ in diameter, but may occasionally reach a length of 20μ. The apex of the emptying tube projects slightly externally, and is sometimes clearly seen to be constricted at the point where it pierces the wall of the host cell.

On a few occasions I have been fortunate in observing the escape of the zoospores, which rush out from the open end of the emptying tube in a continuous stream, so that the sporangium is soon emptied. The actively swarming zoospores (Pl. XVII, fig. 12), appear when in motion to have a somewhat ovoid form, with a single long flagellum projecting from the more pointed end, but when they come to rest they assume a nearly spherical shape. The body of the zoospore shows a conspicuous dark granule on one side, and often a few smaller scattered granules are present also. The diameter of the zoospore is 3 to 3·5μ, and the length of the flagellum is about four to five times the diameter of the body (12 to 17μ). Some of the zoospores exhibited amoeboid changes in form during the swarming period, which lasted for about twenty to thirty minutes.

The resting sporangia (Pl. XVII, fig. 13) are mostly spherical, with an average diameter of about 20 to 25 μ, but sometimes reaching 30 μ. When the host cell is too narrow for their normal development, they not infrequently assume an elliptical form, with one axis nearly or quite double that of the other. They occasionally occur singly, but usually more than one is found in a host cell. They may be present in the same cell as the temporary sporangia, as is seen in Pl. XVII, fig. 13, where, however, only the empty walls of the latter remain. They possess a thick, nearly colourless wall which is ornamented externally with large, shallow, concave depressions, so that when seen in optical section the resting sporangium shows a star-shaped outline inclosed within a circle. The contents are finely granular with a few larger oil-globules, but in a few cases the interior appeared as if it were divided up into zoospores. The escape of the zoospores from the resting sporangium has, however, not yet been observed.

When the presence of the parasite was first discovered, it was believed to be identical with *Olpidium Brassicae* Woron. (19). Subsequently, however, it was found to show some important differences, *viz.* in the very varied shape and size of the temporary sporangium, as well as in the shorter emptying tubes, and also in the ornamentation of the wall of the resting sporangium. The temporary sporangia closely correspond with those of *O. Borzii* described and figured by de Wildeman ((17), *vide* Pl. III, figs. 7–18) and found in the roots of *Brassica oleracea* and *Capsella Bursa-pastoris*. This name was subsequently changed by de Wildeman (18) to *O. radicicolum**. The resting sporangia, on the other hand, agree with those of *Asterocystis radicis* de Wildeman, figures and descriptions of which are contained also in his earlier paper ((17), Pl. III, figs. 1–6, 19), which was likewise found in the roots of Cruciferae, as well as in plants belonging to some other families.

Since I have repeatedly found both the temporary and resting sporangia in the same root, or even in the same host cell, there appears to me to be little doubt that both belong to the same species. I have corresponded with Dr E. de Wildeman, who has very kindly supplied me with copies of his publications upon this subject, and he agrees with me that the name, *O. radicicolum* de Wildeman should be retained for this species, since in his earlier paper (17), this name precedes that of *A. radicis*, which must therefore disappear. In 1901, Marchal published a paper dealing with a parasite found in the roots of cultivated flax in Belgium, which he identified as *A. radicis*. He observed

* [This change of name was presumably because of the previously existing name *O. Borzianum* Morini (1887), but is unwarranted. Eds.]

both the resting and temporary sporangia, and his figures show that they are probably identical with the fungus in the roots of swedes, although he failed to notice the emptying tubes of the temporary sporangia. Marchal found that this parasite was responsible for a disease in which the young flax plants were temporarily arrested in their growth, and under unfavourable conditions became yellow and died. A similar disease has been met with in Ireland and in several places on the continent. An account by Miss J. H. H. van der Meer of an *Olpidium* disease of cauliflower seedlings in the neighbourhood of Utrecht, appeared in 1926. The seedlings showed the effects of the parasite after transplantation into the field, when many of them ceased to grow and their root system was found to be poorly developed. The infected roots showed a yellowish brown discoloration, and a microscopic examination disclosed the presence of the temporary sporangia of an *Olpidium*, but no resting sporangia were observed. She was uncertain as to the precise identity of the species, but the figures and measurements of the temporary sporangia and of the zoospores agree very closely with those of *O. radicicolum*. She states, however, that the most elongated sporangia bore from two to six "necks," *i.e.* emptying tubes, but none of her figures show more than one, and in no instance have I observed more than three. The *Olpidium* was found in roots of both cauliflower and cabbage in two different localities, also sporadically in *Chenopodium* and beet. Thus, it appears to have rather a wide distribution. The penetration of a zoospore into a root hair was observed, the total time taken from the penetration to the development of the mature sporangium and the escape of a fresh generation of zoospores being forty-four hours.

Miss van der Meer also states that most of the plants apparently attacked, although suffering a diminution of total weight amounting in most instances to not less than twenty-five per cent., had recovered by June.

Chupp (4), in the course of his investigations on *Plasmodiophora Brassicae* in America, occasionally came across what appeared to be the temporary sporangia of an *Olpidium*, but the specific identity was uncertain. He states that the organism evidently enters by the root hairs, never penetrates far into the host, and causes no change in the size or the general appearance of the invaded cells.

Mlle Bensaude (1), also in America, found a species of *Olpidium* parasitic in roots of seedling plants of tomato, tobacco and cabbage, which she identified as *O. Brassicae*. She observed both the temporary and the resting sporangia, but not the mature zoospores. She reports that the infected plants developed normally.

In the course of these investigations I have occasionally come across what I believe to be the temporary sporangia of *O. Brassicae* (Woron.) Dang. (Pl. XVII, fig. 14) in the finer roots of swedes. From Woronin's descriptions and figures (19) the sporangia of this species are characterised by their form being always more or less spherical, and by their long, sinuous emptying tubes. The wall of the sporangium appears to be thicker than in *O. radicicolum*, and in optical section shows a distinct double contour. Neither Cooke (5) in his *Handbook of the British Fungi*, nor Massee (11) in *British Fungi*, nor Ramsbottom (15) in "A List of the British Species of Phycomycetes, etc." mention either *Olpidium Brassicae* or *O. radicicolum*. I believe that this is the first recorded occurrence in Great Britain of these two species of *Olpidium*.

Characters of the Nodules.

The nodules (Pl. XVI, figs. 1 to 4) are borne laterally, either upon the main root or upon the larger branches of swedes to which they are attached by a narrow base, below the surface of the soil. They vary considerably in size, from about that of a pea upwards. The largest nodules met with measure rather more than 2 cm. in their greatest diameter. The younger nodules are more or less spherical, but as they increase in size they tend to assume an irregular form. The surface is uneven and wrinkled, and is usually covered with smaller nodulosities.

The colour is at first the same as that of the roots which bear them, *i.e.* a yellowish white. As they become older, however, they exhibit a peculiar tendency to become green, owing to the development of chlorophyll, which causes them to stand out in strong contrast with the roots bearing them. This phenomenon may be easily overlooked, because it appears only after a time, when the swede is kept alive by immersing the roots in a jar of water and when the roots are exposed to light.

Another curious characteristic which, as already mentioned, has attracted the attention of previous observers, is the production of blanched shoots bearing leaves (Pl. XVI, fig. 4), which also become green on exposure to light. These shoots spring either from the nodules themselves, or from between the nodules and the roots bearing them. It is an interesting fact that the development of chlorophyll in the nodules and the formation of leafy shoots, both of which phenomena are principally confined to the sub-aerial parts of plants, should appear in parts of the roots which are normally deeply buried in the soil. That the nodules represent metamorphosed lateral roots is rendered probable both by the fact that they possess vascular bundles, and from their occurrence on two opposite

sides of the main root where they occupy the positions of the lateral roots. Rootlets are occasionally found with a small rounded swelling at their bases indicating the probable mode of origin of nodules.

A section of a nodule examined under the microscope is seen to consist of rather large, clear, thin-walled parenchyma cells between which are numerous intercellular spaces. Strands of vascular tissue pursue a very irregular course through the parenchyma and are sometimes bent back upon themselves so as to form loops. Conspicuous elements of the vascular strands are tracheids with short transverse pits covering their walls. A tissue resembling periderm in the form and arrangement of its cells forms a layer a short distance below the surface of the nodule, but the cell walls are thin and colourless. The parenchyma cells contain small starch grains, and clustered crystals of calcium oxalate are sometimes present.

No trace of any parasite could be found within the nodules themselves, but *Olpidium* was usually abundant in the rootlets which spring in large numbers from the bases of the nodules. The absence of *Olpidium* within the nodules may possibly be explained by the formation of the periderm layer at an early stage in the development of the nodule, so that the layers of cells outside the periderm die and become disorganised. The *Olpidium*, on the other hand, is present only in the outermost layers of cells and only in the very young roots; none can be found in the roots of older growth. Since the nodules take the place of some of the lateral roots, they likewise make their first appearance, as I have been able to observe, at a short distance behind the apex, and at a very early stage in the growth of the root which bears them. During the passage of a lateral root through the cortex to reach the exterior, I believe that the cells of its growing point are stimulated by the action of the parasitic *Olpidium* to an abnormal growth, so that the root develops into a nodule. The development of a number of rootlets from the place of attachment of the nodule may be a reaction on the part of the plant to provide for its water supply, since the nodule is not adapted to absorb water.

The accounts of the nodules given by Caspary (2) and Helweg (7) agree very closely with my own observations. Helweg, however, states that they vary in size from a hen's egg downwards, and that exceptionally they reach a diameter of 10 to 15 cm. Sometimes they may entirely take the place of the root itself. Caspary considers that the nodules represent metamorphosed roots of the second and third orders, because the vascular strands from the roots upon which they arise pass into them. He remarks that the vascular strands, which were already

bent into a circle close to the base of the tubercle, were seen to be joined up with the stele of the root to which they were attached. Hence, he concludes, that at the time when the tubercle was formed, the portion of the root bearing it was very young, and its vascular bundle still wholly in the cambial state, because otherwise branching would have been impossible. Neither Caspary nor Helweg was able to find any trace of any organism in the nodules, nor any external injury which could have caused their formation.

Through the kindness of Professor M. C. Potter, when this paper was almost ready for publication, three cauliflower roots bearing outgrowths very similar in some respects to those described above as occurring on swedes, were received from his garden at New Milton in Hampshire. All three roots bore numerous closely crowded, blanched, adventitious shoots, arranged in two opposite rows along some of the main roots, and occupying the positions of the lateral roots. These shoots consisted mainly of a few etiolated leaves with short fleshy petioles each bearing a small, yellowish, rudimentary lamina at its apex. The majority of these shoots measured less than one inch in length, but one of them was about six inches long and had evidently appeared above the surface of the soil, because its apical leaves had become green and had developed a lamina; the total length of these leaves was about two and a half inches. On other parts of the roots were found small nodules of an irregular shape, and also the characteristic tufted rootlets. Most of the finer rootlets had been rubbed off or torn away, nevertheless a microscopical examination disclosed the presence of numerous temporary and a few resting sporangia of *O. radicicolum* in all three roots.

Thus, these specimens help to support my view that certain characteristic nodular formations and adventitious shoots occurring on roots of Cruciferae, and stated to be characteristic of swede and turnip hybrids, are probably always due to the presence of the parasite, *O. radicicolum*.

Infection Experiments.

With the object of ascertaining whether the *Olpidium* from the roots of the mature swede-bearing nodules could also infect seedlings, swede seeds were sown in two flower pots of ordinary garden soil, one of which it was intended to keep as a control. Through an accident some of the water from the jar in which the infected swede was growing, and which contained liberated zoospores of *Olpidium*, was added to *both* pots. Within fourteen days some of the seedlings appeared unhealthy in both pots and began to droop. These were shorter in length than the rest, the

tissues of the hypocotyl appeared watery and translucent, and the cotyledons were often yellowish and showed black spots. When subjected to a microscopical examination, *Olpidium* was found abundantly in all the unhealthy seedlings examined, particularly in the region of the "collar" which was brownish, and often throughout the root. The root itself was usually poorly developed. Finally, most of the seedlings drooped and died, and *Olpidium* was found to be plentiful in all the dead ones. No *Pythium* could be detected in the early stage of the experiment when the seedlings began to die, although a few hyphae were observed later on. Thus the death of the seedlings in both pots appeared to be almost wholly due to *Olpidium*, but it is unfortunate that the experiment was vitiated by the absence of a control.

In subsequent experiments, seeds of swede, white turnip and cabbage were each sown in two pots of soil. After the seeds had begun to germinate, one pot of each kind was inoculated by adding water in which an infected swede was growing, whilst the other pot was kept as a control and watered only with ordinary tap-water. Within five weeks most of the swede and turnip and about one-third of the cabbage seedlings had died. Drooping or dead seedlings were examined from time to time, and all of them showed *Olpidium*, either in the root, the collar, or in both. *Pythium* was almost entirely absent throughout the experiment. In the control pots very few seedlings died, and in none of them was *Olpidium* found.

In another experiment, swede seeds were sown in pots filled with soil taken from a garden plot which produced several swedes bearing nodules. A large proportion of the seedlings became infected and died, and plenty of *Olpidium* was found in their roots. Seeds of white mustard and garden cress were sown in pots, some of which were inoculated as before, whilst others were kept as controls. Some of the seedlings in both sets of pots died, and when examined microscopically they were found to be attacked by *Pythium*, and I did not come across one which would lead me to the conclusion that death or drooping was due to *Olpidium*. I found several in which the zoospores of *Olpidium* had found their way into the root hairs or into the cells of the piliferous layer, but had developed no further. A few small, immature temporary sporangia were seen, sometimes more than one being present in a host cell.

These experiments, performed in the laboratory, show that under certain conditions *O. radicicolum* may be very injurious to seedlings of swede and turnip, and to a much less degree to those of cabbage, but, on the other hand, seedlings of garden cress and mustard appear to suffer little from its attacks. The

suggestion is put forward that attacks by *O. radicicolum* may be responsible for the gaps in the rows or for partial failures often experienced in the sowings of swede or turnip seeds in fields during abnormally wet seasons.

The experiments described above were carried out before I had seen the papers by Marchal (10) and Miss van der Meer (12), and in part confirm the results obtained by these two observers. Thus, Marchal found that zoospores of *A. radicis* (= *O. radicicolum*) from flax very readily infected seedlings of turnip, but only slightly those of mustard. Miss van der Meer reports that cabbage and cauliflower seedlings suffered little beyond a retardation in their growth, from the attacks of this parasite, and that most of the plants recovered later. Her experience agrees with my own in that infection with *Olpidium* depends very largely for its success upon the humidity of the soil. Marchal found evidence for the existence of physiological races or specialised forms in connection with this parasite. Attempts on my part to infect pots of flax seedlings with *Olpidium* from swede yielded only negative results, perhaps, for this reason.

In March, 1925, a plot experiment was started in the newly created Botanic Garden of Armstrong College on soil which has been pasture-land for as long as anyone can remember. Two plots were selected, separated from one another by a few intervening ones, and one of these was infected with some soil taken from an allotment bed from which a crop of swedes bearing the characteristic nodules had been gathered. The infected soil was spread as evenly as possible over the surface of the bed, and then thoroughly incorporated with the soil of the plot. The other plot, which was not inoculated, was kept as a control. Upon both plots two rows of swede and two rows of turnip seeds were sown, and in May the rows were thinned out, leaving the remaining plants a few inches apart. During the third week in September all the swedes and turnips in both plots were pulled up in batches and examined in the laboratory. Many turnips and some swedes had bolted at an early date, producing long shoots bearing inflorescences, and poorly developed roots, which I was informed was due to the sowing having been done too early in the year. Owing probably to the thinning out having been done unevenly, as well as possibly to the inevitable "leakage," the total number of roots yielded by the inoculated plot was considerably in excess of that obtained from the uninfected bed. Of the one hundred and four turnips harvested from the infected bed none showed nodules, whilst out of a total of one hundred and thirty-six swedes, sixteen bore nodules. From the control bed sixty-one swedes were obtained, and only one showed small nodules, and *Olpidium* was found in the roots. Out of eighty-

six turnips from the same bed, three showed some small rounded swellings, and in the roots of two of these *Olpidium* was discovered. The occasional occurrence of infected swedes or turnips on the control plot may be explained by the many possible sources of contamination, *e.g.* by means of the gardeners' tools or boots, bird or animal agency, etc., particularly on account of the two beds being separated from one another by the space of only a few yards. It should be observed that some of the swedes from the infected plot were of small size and possessed small unthickened roots, and it is not unlikely that the frequent presence of *Olpidium* in these may have been responsible for the poor development of the plants as a whole. This experiment appears to show that the occurrence of nodules on roots of swedes depends upon the presence of *Olpidium* in the soil, and that swedes grown in soil containing no *Olpidium* are without nodules.

The plot experiment was repeated in 1926 on the same two garden plots, on each of which two rows of swedes and one row each of white turnip and cabbage were grown. The crops were harvested in October, and none of the turnips or cabbages from both plots bore any nodules upon the roots. Of sixty-nine swedes from the infected plot nineteen had nodules, and of forty-nine swedes from the control plot ten showed nodules, all but two being very slightly affected. The percentages of affected swedes in these two plots amounted to 27·5 and 20·4 respectively. Since the microscopical examination of the affected roots invariably showed the presence of *Olpidium*, this last experiment must be regarded as unsatisfactory, owing to the increased contamination of the control plot.

O. radicicolum THE CAUSE OF "HYBRIDISATION NODULES."

The evidence in support of *O. radicicolum* being the primary cause of the so-called "hybridisation nodules" may now be considered. In the first place, there is the fact that since the presence of the parasite in the roots of swedes bearing these nodules was first discovered in December 1924, I have examined a large number of swedes affected in this way, and have seldom failed to find this *Olpidium* in abundance in some of the smaller roots. The swedes have been obtained from various fields and gardens scattered about the district. In the only other plants with similar abnormal outgrowths which I have had the opportunity of examining, *viz.* three turnips and the roots of three cauliflowers, *Olpidium* was found in all the cauliflowers and in two of the turnips. Secondly, there are the plot experiments reported above. From the same sample of swede seed, some of which was sown in soil previously inoculated with the parasite,

11·76 per cent. of the swedes harvested bore nodules, whilst on the control plot only a single root, or 1·61 per cent. of the whole, showed a few nodules due to an accidental contamination. It is to be regretted that the plot experiment, repeated during the following year, was useless owing to greatly increased contamination of the control plot. Microscopical examination showed that *Olpidium* was present in the roots of every affected swede from both plots.

Helweg (7, 8) contended that "hybridisation nodules" occur only on hybrids obtained by crossing swedes with "wild turnip" or turnip, or by crossing turnip with rape or swede. Such, however, is not invariably the case as is shown by the fact that nodules, "tubers" or other abnormal growths showing the characteristic features of "hybridisation nodules" have been described upon the roots of other cultivated Cruciferous plants, *viz.* brussels sprouts, rape, kohlrabi, cabbage and cauliflower, to which references have already been made.

Moreover, Helweg's experiments, designed with the object of proving the hereditary character of the nodules produced on swede and turnip hybrids, furnished results which are directly opposed to this view. For example, he reports that of a sample of swede seed purchased from an English seed firm some was sown on shelves in a forcing shed, and some in a cold frame. Of the plants raised in the shed ninety per cent. bore nodules of various sizes, often with several adventitious shoots springing from the nodules, but no nodules were present upon the plants grown in the frames. The conclusion drawn by Helweg from these results is that it must have been the sowing of the seed in a warm house in December which caused nodules and adventitious shoots to develop in the one case and not in the other. Hence, he states, *the method of cultivation must have the same effect on the swedes as a crossing with "Rybs**."* But this conclusion is negatived by the fact that of the two other samples of swede seed sown at the same time and under the same conditions, neither of these produced plants with nodules, either in the forcing shed or in the cold frame.

The results of Helweg's experiments and his recorded observations, so far from proving the hereditary character of the nodules, would lead one to draw the opposite conclusion. But these apparently contradictory results, as well as Caspary's experiments, become intelligible if the appearance or non-appearance of nodules depends upon the presence or absence of *O. radicicolum* in the soils in which the plants are grown. Helweg himself states that certain kinds of soil favour the formation of these excrescences, whilst in other soils their production

* Rybs = Rübsen (*Brassica rapa rapifera*).

is suppressed, or at any rate is less pronounced. It would appear from the above statement that the presence or absence of some factor in the soil may partially or entirely overcome the supposed influence of heredity. This factor is probably none other than *O. radicicolum*.

Even if the nodules are most frequently observed on the roots of hybrids of swede, turnip and rape, as Helweg contends, this fact by no means explains how they are produced. In the other two well-known instances of gall-like swellings or deformities occurring on roots of cruciferous plants, definite parasitic organisms are known to be concerned, *viz.* either *Plasmodiophora Brassicae* or the larva of *Ceuthorhyncus sulcicollis* Gyll. Therefore, from *a priori* considerations we might also reasonably expect some parasite to be the exciting cause in the production of the so-called "hybridisation nodules."

Helweg's contention that the nodules are characteristic of swede, turnip and rape hybrids may be explained by the possibility that the roots of these hybrids react more vigorously to the attacks of *Olpidium*. Although, as is well known, the progeny resulting from interspecific hybridisation frequently show a surprising vigour, occasionally the hybrids are conspicuously weak. Sometimes the growth reactions in the hybrid appear to be rather delicately balanced, so that unsuitable conditions, particularly in early life, may affect it, whilst similar conditions may have no noticeable influence on the growth of the parental species. These considerations may possibly furnish an explanation why some hybrids produce nodules in the presence of the *Olpidium*, apparently more frequently than do the species from which they have been derived.

It still remains to be proved, however, that the nodules can appear on the roots of hybrid swedes or turnips when these are grown in soil which does not contain *Olpidium*. The onus of proof rests with those who believe in the "hybridisation nodules" hypothesis. During the present season some experiments have been started to ascertain whether nodules can be produced on swedes guaranteed to be of pure strain when grown in infected plots. Through the kindness of Messrs Sutton and Son, of Reading, three varieties of swede seeds, described as the direct produce of fine, large, apparently healthy, pure roots, selected in the North and brought down to Reading to seed, have been received and sown.

In conclusion, I desire to take this opportunity of expressing my gratitude to Dr G. H. Pethybridge for bringing to my notice some publications bearing upon the subject of this investigation, as well as for lending me certain of these papers which I had a difficulty in obtaining otherwise.

Supplementary Note.

In the new edition of *Die Pflanzenkrankheiten der Kulturgewächse*, 1 Teil (1927) by J. Eriksson, which appeared after the completion of this paper, the name *Asterocystis radicis* de Wild. is altered to *Olpidiaster radicis* (de Wild.) Pasch. (*vide* pp. 53–4), because the former generic name had been previously given to a genus of Algae. This new name, however, must also give way to *Olpidium radicicolum* de Wild. for the reasons stated above in the body of this paper.

SUMMARY.

1. In addition to the deformities produced on the roots of cultivated cruciferous plants by the attacks of *Plasmodiophora Brassicae* and a beetle (*Ceuthorhyncus sulcicollis*) are those which have received the name "hybridisation nodules" and in connection with which no parasitic organism has hitherto been observed.

2. Two characters apparently peculiar to "hybridisation nodules" are their tendency to become green when they are exposed to the light, owing to the development of chlorophyll, and the production sometimes of blanched adventitious shoots bearing leaves from the underground parts of the roots, which also turn green in the presence of light.

3. Outgrowths resembling "hybridisation nodules" have been met with on the roots of swede, turnip, rape, kohlrabi, cabbage, cauliflower, and brussels sprouts.

4. The nodules represent metamorphosed roots of the second and third orders.

5. In the finer roots of numerous swedes, and of a few cauliflowers bearing "hybridisation nodules" examined microscopically, a Chytridiaceous parasite, *Olpidium radicicolum* de Wildeman has been constantly found, but not in the nodules themselves.

6. Both the temporary and the resting sporangia, as well as the escape of the zoospores from the former, have been observed in the fungus. *O. Brassicae* (Wor.) Dang. was also occasionally encountered.

7. The name *Asterocystis radicis* was given by de Wildeman to the resting sporangia of *Olpidium radicicolum* and must therefore give way to the latter name on the grounds of priority. *Olpidiaster radicis* (de Wild.) Pasch. is also untenable.

8. It has been shown by pot experiments that under certain conditions *Olpidium radicicolum* present in the soil may be very destructive to seedling plants of swede and turnip, in a lesser degree to those of cabbage, and scarcely, if at all, to those of

white mustard and garden cress. It is suggested that the gaps in the rows and partial failures in the sowings, sometimes observed in swede and turnip fields in exceptionally wet seasons, may be caused by the attacks of *O. radicicolum*.

9. In a plot experiment with swedes grown in soil artificially infected with this parasite, several plants bore "hybridisation nodules," whilst on the control plot, nodules were only occasionally observed and this was found to be due to accidental contamination by *O. radicicolum*. Turnips grown in infected soil very rarely produced nodules, and none were found in cabbages.

10. In the discussion reference is made to certain previous experiments, carried out in the endeavour to prove that "hybridisation nodules" believed to be characteristic of certain hybrids and therefore of an hereditary character, which produced very inconclusive or even contradictory results. These results, however, are rendered intelligible by the discovery of a parasite, which, according to its presence or absence in any particular soil, may cause the production or not of nodules.

11. The fact that these nodules appear to be more plentiful on the roots of certain hybrids of swede, turnip and rape may possibly find its explanation in the common experience that hybrids are sometimes affected, particularly in early life, by more or less unsuitable conditions, which latter may have no noticeable influence on the growth of the parental species. It has not yet been proved that nodules can be formed on hybrids, when grown in soil, from which *O. radicicolum* is absent.

12. This is believed to be the first recorded occurrence of *O. radicicolum* and *O. Brassicae* in Great Britain.

REFERENCES.

(1) Bensaude, M. A species of *Olpidium* parasitic in the Roots of Tomato, Tobacco and Cabbage. Phytopathology, XIII (1922), 451–454.

(2) Caspary, R. Eine Wruke (*Brassica Napus* L.) mit Laubsprossen auf knolligen Wurzelausschlag. Schriften Physik-Oekonom. Ges. zu Königsberg, XIV (1873), 109–112.

(3) —— Hereditary Deformity in *Brassica napus*. The Gardeners' Chronicle, VII, N.S. (1877), 148.

(4) Chupp, R. Studies on Clubroot of Cruciferous Plants. Cornell Univ. Agric. Exp. Sta. Bull. 387 (1917), 421–452.

(5) Cooke, M. C. Handbook of British Fungi. London, 1883–5.

(6) Dangeard, P. A. Recherches sur les Organismes Inférieurs. Ann. Sci. Nat. Bot. VII, 4 (1886), 241–341.

(7) Helweg, L. Kaalroens og Turnipsens Bastarder og de med Disse naer Besloegtede Kulturformer. Tidsskrift for Landbrukets Planteavl. Copenhagen, XVII (1910), 529–583.

(8) —— Root-Nodosities of Crosses between Swedes and Turnips. Internat. Inst. Agric. Rome. Monthly Bull. Agric. Int. and Plant Diseases. Year V, No. 7 (1914), 833–386.

(9) Kühn, J. Die Krankheiten der Kulturgewächse, ihre Ursachen und ihre Verhütung. Berlin, 1858.

(10) MARCHAL, E. Recherches Biologiques sur un Chytridinée parasite du Lin. Bull. de l'Agric. Belg. (1901), 1–46.
(11) MASSEE, G. British Fungi. London, 1891.
(12) MEER, J. H. H. van der. The *Rhizoctonia* and *Olpidium* Disease of Cauliflower Seedlings. Tijdschrift over Plantenziekten, XXXII (1926), 209–242.
(13) PETERS, L. and SCHWARTZ, M. Krankheiten und Beschädigungen des Tabaks. Mitt. Kais. Biol. Anst. f. Land- und Forstw. XIII (1912), 9–10.
(14) Ministry of Agriculture and Fisheries of Great Britain, Revised Leaflet, No. 77, Finger-and-Toe Disease (1926), 1–6.
(15) RAMSBOTTOM, J. A List of the British Species of Phycomycetes, etc. with a Key to the Genera. Trans. Brit. Myc. Soc. V (1914–16), 304–317.
(16) SORAUER, P. Handbuch der Pflanzenkrankheiten, II, 1, 142. 1921.
(17) WILDEMAN, E. DE. Notes Mycologiques. III. Sur quelques Champignons parasites dans les Racines des Phanérogams. Ann. Soc. Belge de Microscopie, XVII, 1 (1893), 12–28.
(18) —— Census Chytridinearum. Mém. Soc. Roy. Bot. de Belgique, XXXV (1896), 7–69.
(19) WORONIN, M. *Plasmodiophora Brassicae*, Urheber der Kohlpflanzenhernie. Jahrbuch. Wiss. Bot. XI (1878), 548–574.

EXPLANATION OF PLATES XVI, XVII.

Figs. 1 to 13. *Olpidium radicicolum* de Wildeman.

PLATE XVI.

Figs. 1 to 4. Photographs of roots of swedes bearing "hybridisation nodules" ($\times\frac{1}{4}$). Fig. 4 shows a tuft of leafy adventitious shoots springing from a part of the root buried in the soil.

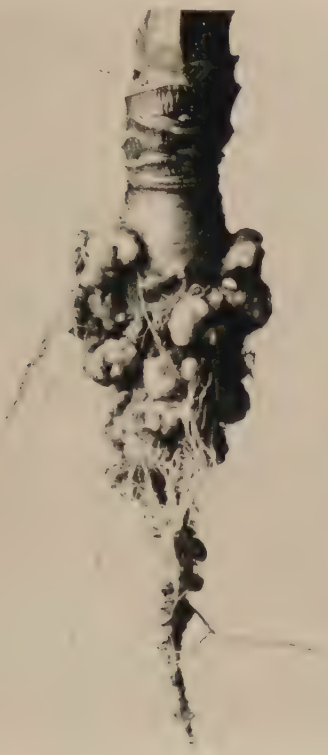
PLATE XVII.

Fig. 5. Part of a fine root of a swede with cells containing temporary sporangia. $\times 350$.
Fig. 6. A temporary sporangium. $\times 350$.
Fig. 7. A temporary sporangium with two emptying tubes. $\times 620$.
Fig. 8. Part of root hair of swede containing several temporary sporangia with emptying tubes, from some of which the zoospores have escaped. $\times 620$.
Fig. 9. Temporary sporangia showing irregular forms. $\times 200$.
Fig. 10. Temporary sporangium in root hair of cabbage. $\times 620$.
Fig. 11. Temporary sporangium in root of swede. $\times 380$.
Fig. 12. Zoospores. $\times 5000$.
Fig. 13. Root cell of swede containing resting sporangia and empty walls of temporary sporangia. $\times 500$.
Fig. 14. Temporary sporangia of *Olpidium Brassicae* (Wor.) Dang. with long emptying tubes, in root cells of seedling swede. $\times 500$.

TROPICAL ROOT DISEASE FUNGI.

By T. Petch, B.A., B.Sc.

THE following notes, which have been compiled at the request of several mycologists, are intended to furnish a review of the present position of the nomenclature of some of the fungi which cause the principal root diseases of plantation crops in the Eastern tropics.



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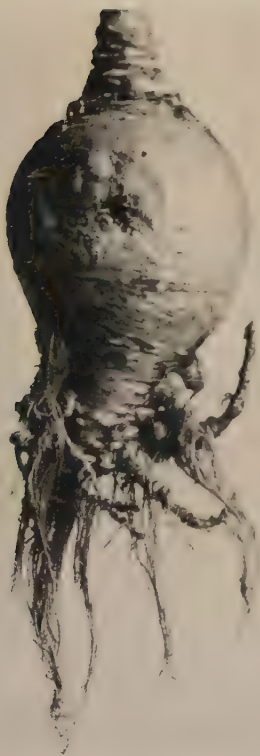

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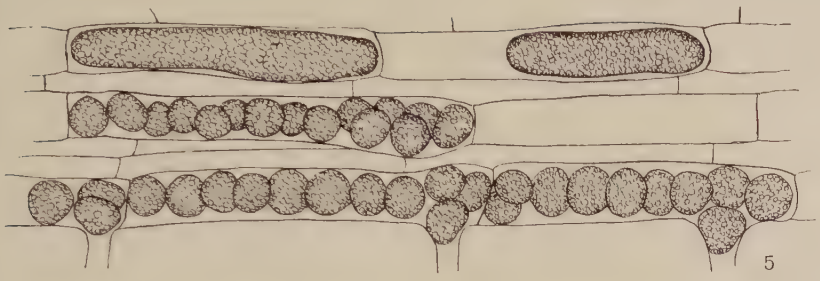
"HYBRIDISATION NODULES" OF SWEDES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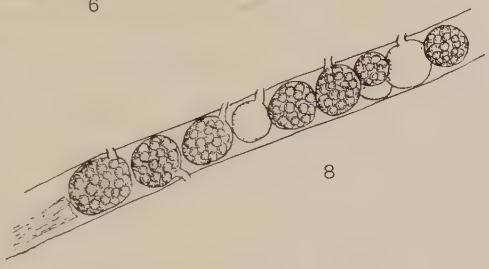
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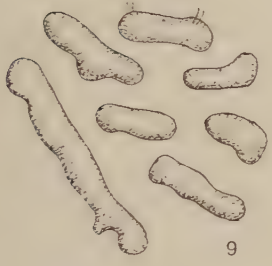
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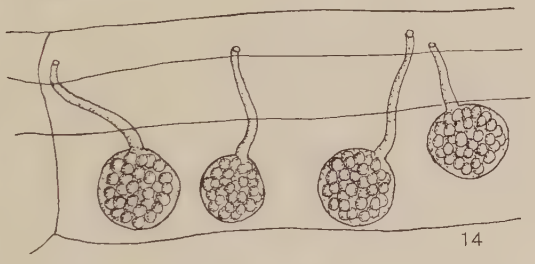
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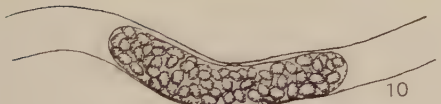
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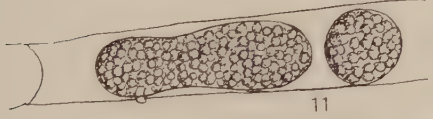
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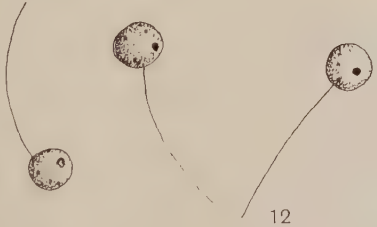
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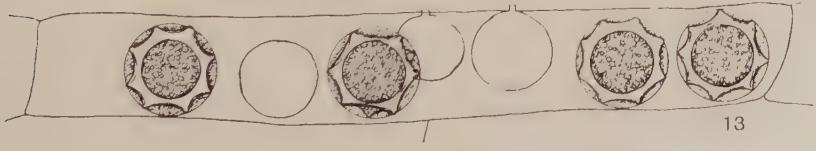
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Armillaria mellea (Vahl) Fr.

In the *Ann. Royal Bot. Gard., Peradeniya*, IV, p. 299, I described a new species of *Armillaria*, *A. fuscipes*, which had been found to cause a root disease of *Acacia decurrens*, and an account of this disease, with a photograph of the fungus, was published in *Circulars and Agricult. Journ. Royal Bot. Gard. Ceylon*, V (1910), no. 10.

In 1918 Bernard and Palm published an account of the root diseases of tea in Java in *Meded. van het Proefstation voor Thee*, LXI, including one which was caused by an *Armillaria* which they referred to *Armillaria mellea*.

In West Africa, a similar root disease is known to attack cacao and other plants, and here again the causal fungus has been identified as *A. mellea*. The disease has been well described by Bunting and Dade, with good illustrations, in *Gold Coast Plant Diseases*.

The gross characters of the *Armillaria* root diseases in these countries are the same. A peculiar feature is that, in general, the tap root and the lower part of the stem split longitudinally and radially. Hence the disease is known in Java as the Split Root disease, and in West Africa as Collar Crack. The cracks, which extend deep into the wood, may be filled by a tough sheet of mycelium, and plates of mycelium may occur between the wood and the bark, but these symptoms vary on different hosts. The *Armillaria* possesses rhizomorphs and grows in tufts.

In Ceylon the leathery plates of mycelium become red-brown externally. Bunting and Dade state that the outgrowths of these plates from the cracks become yellow and then deep brown. The rhizomorphs, grown in pot culture in Ceylon, were deep red-brown, and this colour was considered a point of difference from *A. mellea*; but examination of the latter in England in the autumn of 1925 showed that the younger parts of the rhizomorphs in that species are red-brown.

From the descriptions and figures which have been published there does not appear to be any doubt that the *Armillaria* root diseases of Ceylon, Java and West Africa are the same. But is the fungus, *A. mellea*?

A. fuscipes Petch is similar in habit to *A. mellea*, arising in tufts from a basal cushion, but its clusters contain fewer individuals and, in general, these are more slender than *A. mellea*. The general structure is the same, the principal difference being in the colour. *A. fuscipes* has practically a white pileus and gills, being brown or yellow-brown only in the centre, where there are also a few minute, distant, brown warts. The stalk is blackish brown, or sepia coloured, and floccose. Bunting and

Dade describe the pileus of their species as cream-coloured, with the remains of the velum persisting as small brown dots, and it is evident from their photograph that the stalk is dark and floccose.

A comparison of the photograph of *Armillaria mellea* in Bunting and Dade's book with that of *A. fuscipes* in *Circulars and Agricult. Journ. Royal Bot. Gard. Ceylon*, will show the close resemblance between the West African and the Ceylon fungus; and when it is understood that the latter photograph was taken on an Ilford ordinary plate, it will be granted that this *Armillaria* has a white, not a honey-coloured, pileus and gills.

That *A. fuscipes* is the tropical analogue of *A. mellea* is undoubtedly correct, but I do not think that they can be regarded as the same species.

Ustulina zonata (Lév.) Sacc.

In 1907 a root disease of tea was found in Ceylon, caused by a species of *Ustulina*, the fungus being recorded as an undescribed species of *Ustulina*, which, however, Berkeley and Broome had identified as *U. vulgaris* Tul. (Report of the Government Mycologist for 1907, etc.). An account of the disease was published in the *Tropical Agriculturist*, xxviii (May, 1907), pp. 292–5, and reproduced (in part) in the *Gardeners' Chronicle*, xlii (Nov. 23rd, 1907), p. 362, specimens of the Ceylon fungus, with European examples of *U. vulgaris* for comparison, having been exhibited before the Scientific Committee of the Royal Horticultural Society. The Ceylon specimen exhibited was the common form, a thin circular plate, up to 10 cm. diameter, not exceeding 3 mm. in thickness in the centre, purple-grey in colour. Subsequently it was considered to be identical with *U. zonata* (Lév.) Sacc., and this name has been generally adopted for it. It is known to cause root disease in a large number of cultivated plants in the Eastern Tropics.

Von Höhnel, who collected the fungus in Java in 1907–8, also adopted the name *U. zonata* (*Frag. z. Mykolog.* vi Mitt.). He may, however, have been influenced by his belief that its conidial stage was a *Graphium*, and consequently different from the conidial stage of *U. vulgaris*. In that he was mistaken. The conidial stage of our *Ustulina* is common in Ceylon, the stroma being always, in my experience, conidial at first, and bearing hyaline conidia on closely-packed conidiophores over the whole of its upper surface.

The late Dr Patouillard, in conversation, informed me that he considered *U. zonata* the tropical form of *U. vulgaris* Tul.

U. zonata was described by Léveillé as *Sphaeria* (*glebosa*)

zonata in *Ann. Sci. Nat.*, Ser. 3, III (1845), p. 48, from specimens collected in Java. His description is:

"253. *Sphaeria* (*glebosa*) *zonata*, nov. sp. Effusa undulata, zonata e fusco nigricans, peritheciis oblongis stromate nigro carbonaceo immersis, ostiolis minimis punctiformibus nigris. Hab. Java, ad palmas. Zippelius (herb. Lugd. Batav.).

"Cette espèce est voisine du *Sphaeria deusta*, mais elle s'en distingue facilement parce qu'elle est d'une couleur rousse et que sa surface est marquée de zones concentriques, caractère qui n'a encore été indiqué dans aucune espèce. Les réceptacles sont elliptiques, plongés dans un stroma noir charbonneux développé entre les fibres des palmiers. Leur nucléus est composé de paraphyses et de thèques filiformes qui renferment huit spores ovales allongées, sans cloisons et disposées sur une seule ligne."

It is to be noted that in the same list, immediately prior to *Sphaeria zonata*, Léveillé recorded "252. *Sphaeria* (*glebosa*) *deusta* Hoffm. Hab. Java, ad truncos, Sphaeria no. 1001. Zippelius (Herb. Lugd. Batav.)," *i.e. Ustulina vulgaris* Tul.

I have not seen the type of *U. zonata*. I was unable to find a Léveillé specimen under that name in Herb. Paris. There is, however, a Léveillé specimen marked "*Sphaeria* (*glebosa*) *deusta* Hoffm. Java. ad truncos. Lév." which throws an interesting side-light on Léveillé's views. This is an irregularly undulating fragment, not zoned, but with a reddish tinge, and, as far as can be determined without examination of the spores, it is the species now generally assigned in the eastern tropics to *U. zonata*.

Léveillé distinguished *U. zonata* from *U. vulgaris* by its reddish colour and its zoned surface. The "zones" are narrow, depressed, concentric rings, their common centre being situated above the point of attachment of the stroma. But neither of these features is constant. The stroma is fairly frequently reddish on the surface, wholly or in part, but the majority of the specimens are, until weathered, grey or purple-grey. When weathered, they are, of course, black. The zonation is also a common feature, especially in the case of stromata which develop on an even surface, but it is not universal; it probably indicates periodic arrests of the extension of the stroma over the surface of the host. The zonation is not an indication of immaturity.

From the specimen in Herb. Paris, it would appear that Léveillé described reddish and zoned specimens as *Ustulina* (*Sphaeria*) *zonata*, but when they were not zoned he referred them to *U. vulgaris* (*Sphaeria deusta*), even though they were reddish.

The question was recently reviewed by van Overeem (*Bull.*

Jard. Bot. Buitenzorg, sér. 3, VI (1924), pp. 256–63), who pointed out that, according to the measurements by numerous mycologists, there is no appreciable difference between the ascospores of *U. zonata* and *U. vulgaris*. van Overeem regarded the two as identical.

The extreme form of *U. zonata*, the thin flat plate, appears very different from the usual European form of *U. vulgaris*, but, when developed on soil at the base of a tree, *U. zonata* assumes irregular forms which have the same appearance as the European species. Even in the latter situation, however, the irregular stroma is usually an irregularly undulating plate, with the upper and lower surfaces more or less parallel, instead of the irregularly thickened stroma figured by the Tulasnes for *U. vulgaris*. There is no notable difference in the dimensions of the spores.

van Overeem vouched for the fact that the European form is parasitic on beech in Holland, and stated that it is known to be parasitic on lime in France.

It would therefore appear that *U. zonata* is the tropical form of *U. vulgaris*, as it was regarded by Berkeley. van Overeem adopted for it the name *U. maxima* (Weber) von Wettstein, following Wettstein (*Verhandl. d. zool.-bot. Ges. in Wien*, XXXV (1885), p. 592). *Fide* van Overeem, Weber named it *Sphaeria maxima* in 1778 (*Spicil. Fl. Goetting.*, no. 301, p. 286), following Haller, who listed it in 1768 as *Sphaeria maxima, convexa, nigerrima*. I have not at present an opportunity of referring to any of these papers. But, as van Overeem pointed out, if the rules of the Brussels Congress on nomenclature are accepted, the trivial name which must be adopted is *deusta*, as this name was employed for the species by Fries in his *Systema Mycologicum*. The name to be adopted for both the temperate and tropical forms will then be *Ustulina deusta*.

The red root disease fungi of the East.

In Ceylon two root diseases are known which are characterised by the occurrence of red rhizomorphs on the affected roots. One of these, found chiefly on tea, is caused by *Poria hypolateritia* Berk. The other, which occurs sometimes on tea, but chiefly on *Hevea*, is caused by *P. hypobrunnea* Petch.

The type of *P. hypolateritia*, from Southern India, is one of the specimens which Berkeley left in his herbarium as too fragmentary to warrant the publication of a description. These were afterwards published by Cooke and assigned to "Berk. in herb."

Coloured figures of these two species have been published in *The diseases of the Tea Bush* (1923). *P. hypolateritia* is pinkish or pale red, with a white tomentose margin at first, and white

or cream coloured internally; the basal layer is horny and red or red-brown, and the margin ultimately becomes bright red and glabrous. *P. hypobrunnea* is at first pale ochraceous, then pinkish red, becoming brownish red and finally slate coloured; the context and the basal layer are blackish brown, the basal layer becoming compact when on an even surface but being loose and woolly on an irregular surface or on soil; when fresh, there is usually a reddish tinge on the hymenium and in the context, even in the final slate-coloured stage.

About 1916 a red root disease was found on *Hevea* in Malaya and was at first attributed to *P. hypolateritia* Berk. Subsequently, the fungus was found, on one or two occasions, to produce rudimentary *Fomes* forms, and one of these, "moderately well developed," together with similar forms produced in culture, was sent to Miss Wakefield, who described the fungus under the name *Fomes pseudoferreus* Wakefield (*Kew Bulletin*, no. 6, 1918). The *Poria* form bears some resemblance to *P. hypobrunnea*, but it is quite distinct from *P. hypolateritia*. According to Sharples (*Malayan Agricult. Journ.* XIV (1926), p. 32) no mature fructifications of *F. pseudoferreus* have yet been found in Malaya. The appearance of the diseased roots in the Malayan red root disease is different from that of roots attacked by *P. hypobrunnea*, and the effect of the fungus on the wood also differs (see *Diseases and Pests of the Rubber Tree*, 1921). The roots bear a dark red-brown film here and there, not rhizomorphs.

A red root disease of *Hevea* occurs also in Java, and accounts of this have been published by van Overeem and Steinmann. In *Archief voor de Rubbercultuur*, VII (1923), pp. 453–60, these authors stated that the appearance of the diseased roots in the Javan disease agrees exactly with that described for the red root disease of Ceylon, but does not agree with Belgrave's description (*Dep. of Agric., F.M.S., Bull.* 28) of the red root disease of Malaya. Nevertheless they concluded, from the descriptions, that *F. pseudoferreus* Wakefield and *P. hypobrunnea* Petch were the same fungus, and that these were identical with a fungus found by them on trees attacked by red root disease in Java, which they assigned to *F. ferreus* Berk. Moreover, they changed the name of the last to *Ganoderma ferreum* (Berk.) v. Over. & Steinm. though they had not examined the type.

According to van Overeem and Steinmann in the publication cited (1923),

Ganoderma ferreum (Berk.) v. Over. & Steinm.
= *Fomes ferreus* Berk.
= *Poria hypobrunnea* Petch
= *Fomes pseudoferreus* Wakefield.

The foregoing conclusions, however, were based merely on the presence of red mycelium and a similarity of names. The authors had not examined an authentic specimen of *P. hypobrunnea* nor the types of *F. ferreus* and *F. pseudoferreus*. They found support for their synonymy in my statement, made in 1916, that *F. ferreus* had not been found in Ceylon since the time of the type collection. They suggested that *P. hypobrunnea* was the resupinate form of *F. ferreus*. But neither the pore surface nor the context of these two suggests any relationship. Moreover, when the rubber plantations were "thinned out" from the year 1912 onwards, and the felled trees (at first) left to rot, *P. hypobrunnea* luxuriated on the decaying trunks; but, though thousands of specimens were seen, none ever showed any indication of a bracket.

The true explanation of the apparent failure to find *F. ferreus* again in Ceylon was indicated in my *Preliminary List of Ceylon Polypori*, where it was recorded that the type of *F. ferreus* appeared to be identical with specimens which had been identified for me as *Polyporus semilaccatus*. I have since examined the types of *F. ferreus* Berk. from Ceylon, and *P. semilaccatus* Berk. from the Philippines, in Herb. Kew., and compared them with numerous recent specimens from Ceylon, and in my opinion all these are *F. ferreus*. *F. ferreus* Berk. is identical with the later *P. semilaccatus* Berk., and it is a *Polyporus*, not a *Fomes*.

In 1925 van Overeem published another paper, "Ueber den roten Wurzelpilz," in *Bull. Jard. Bot. Buitenzorg*, sér. 3, VII, pp. 436–43. In that he discarded *F. ferreus* Berk. altogether, and agreed that *F. pseudoferreus* Wakefield is not Berkeley's species. But he still maintained that the Javan and Malayan material was identical, the fungus of red root disease in both countries being *Ganoderma pseudoferreum* (Wakefield) v. Over. & Steinm. That conclusion appears to have been based merely on a study of the literature, the recorded differences in the appearance of the roots and the characters of the fungi being summarily dismissed as errors of the Malayan mycologists. To the synonyms of *G. pseudoferreum*, van Overeem added *Trametes Theae* Zimm., and, with a query, *P. hypolateritia* Berk. and *P. hypobrunnea* Petch. It is astonishing that he should have persisted in his attempt to include the last two, seeing that coloured figures of them were available in the book from which he took my suggestion that *T. Theae* is identical with one of these Porias. But van Overeem was obsessed by the idea that all red root diseases in the eastern tropics are the same.

The present state of our knowledge of these red root diseases may be summarised as follows:

(1) *Fomes ferreus* Berk. is not a *Ganoderma*, and is not connected with a red root disease. It is not known to have red rhizomorphs.

(2) The red root disease of Malaya is caused by *F. pseudoferreus* Wakefield.

(3) The red root disease of Java and Sumatra is caused by a *Ganoderma*. van Overeem considered this identical with *F. pseudoferreus* of Malaya, but as it does not appear that he compared specimens from the two countries this must be regarded as not proved.

(4) Two red root diseases in Ceylon are caused by *Poria hypolateritia* Berk. and *P. hypobrunnea* Petch, respectively. These two fungi are distinct from one another. *P. hypobrunnea* bears some resemblance to *Poria* forms of *F. pseudoferreus*, but Miss Wakefield considers the latter distinct, and the action of the two fungi on the root of *Hevea* is different (specimens from Malaya and Ceylon examined).

Fomes lignosus (Klotzsch).

The fungus considered here under the name "*Fomes lignosus*" is the one which causes the principal root disease of *Hevea brasiliensis* in the eastern tropics. As a root disease, it was first referred to *F. semitostus*, then to *F. lignosus*, and recently to *Rigidoporus microporus*.

F. semitostus Berk. was originally described by Berkeley from specimens collected in India (*Hook. Journ. Bot.* (1854), p. 143). In 1898, it was recorded by Massee in a list of fungi which had been received from Mr H. N. Ridley, Singapore (*Kew Bull.* (1898), p. 117), and in 1904 Ridley published the first account of the root disease of *Hevea* (*Agric. Bull. Straits*, II, pp. 173–5), in which he referred the fungus to *F. semitostus*. The connection between the last two records has not been stated, but Ridley recorded that the disease had been present in the Singapore Botanic Gardens for several years. When the disease appeared in Ceylon in 1905, Mr Ridley kindly furnished me with specimens and a painting of the Singapore fungus, which showed that it was identical with the Ceylon species. The name *F. semitostus* was consequently adopted, and it subsequently came into general use throughout the East.

When identifying Ceylon Polypori at Kew, during my leave in 1910–11, it became evident that the *Hevea* root disease fungus was not *F. semitostus*. Mr C. G. Lloyd, who was then at Kew, had already come to that conclusion, and was endeavouring to arrive at a correct identification. He subsequently referred it to *F. lignosus* (Klotzsch).

In *Synopsis of the Genus Fomes* (1915), p. 230, Lloyd included

F. lignosus as a valid species, stating that "The curious feature of the pores losing the colour in the older portions only, is, as far as I have noted, peculiar to this species, and by this feature I can tell the species at sight. Note: *Polyporus zonalis*, a true annual, is a close relation of *Fomes lignosus*, and not always easy to tell from young *Fomes lignosus*. The coloration and surface of the pileus is the same but the pores do not fade out." Under the synonyms, however, he stated "*microporus* Jamaica Swartz = *Fomes lignosus*, and is the earliest name for it. The type at British Museum is scanty and small, and for a long while I was in doubt whether it was *Polyporus zonalis* or *Fomes lignosus*. Only recently I have been able to satisfy myself." As will be explained later, Lloyd's criterion cannot be accepted; in fact, mycologists in Ceylon distinguish "*F. lignosus*" from *P. zonalis*, in general, by precisely the reverse, when dealing with fresh specimens.

Recently van Overeem collected nearly all the synonyms which have been proposed for *F. lignosus* and *P. zonalis*, and, adopting Murrill's genus *Rigidoporus*, united these two species as *Rigidoporus microporus* (*Icones fung. Malayensium*, v), illustrating it with figures which, with one possible exception, are *P. zonalis* Berk. The rectification of the nomenclature of this rubber root disease fungus has thus become a matter of great difficulty, as it is necessary to compare the types of *F. lignosus*, *P. zonalis*, *P. microporus*, and the type species of Murrill's genus *Rigidoporus*, viz. *P. micromegas*; and these are scattered over Europe in different herbaria, so that a comparison of all the types at the same time is not possible.

In Saccardo, *Sylloge Fungorum*, vi, *Polyporus micromegas* Mont. is given as a synonym of *P. zonalis* Berk., and that view is also taken by Murrill (*Bull. Torr. Bot. Club*, xxxii, p. 478). Lloyd, however, stated (*Synopsis of the section Apus of the genus Polyporus*, p. 382): "*micromegas* Cuba Montagne. Types small and unsatisfactory are at Paris. I think they are the same as *Polyporus Guadelupensis*. They have been referred to *Polyporus zonalis*, but are different in my opinion."

Murrill, in "Polyporaceae of North America" (*Bull. Torr. Bot. Club*, xxx, p. 232), leaves *Fomes microporus* (Sw.) Cke. as "a doubtful or unknown species," though he studied the group in England, where there are specimens in Herb. British Museum.

Much of the confusion which involves "*Fomes lignosus*" is explicable on the supposition that we are dealing with a group of species which, though readily distinguishable when fresh, appear very similar when dry. This is certainly true as regards the Eastern "*F. lignosus*" and *P. zonalis*.

There is no difficulty in distinguishing young "*F. lignosus*"

(of Ceylon) from *P. zonalis*. The former, when young, is deep red-brown, almost dark chestnut, above, with a bright yellow margin and a bright orange pore surface; the pores in section are red-brown, sharply defined from the white context, and do not fade off internally. *P. zonalis*, in its commoner form, is pale yellow-brown, or wood colour, with narrow red-brown zones, a white margin, and a livid or purple-grey pore surface; its pores in section are white or have the purple-grey tinge extending inwards for a short distance.

The "*F. lignosus*" of the East is a large species, attaining a breadth of one foot. As it ages, the upper surface becomes wood coloured, with close-set, narrow, concentric zones; the margin becomes the same colour, and the pore surface red-brown. The upper surface is feebly concentrically sulcate, almost smooth, and faintly radially silky, becoming glabrous. In very old specimens the pore layer in section shows a narrow regular paler zone (pale brown, not white) next to the context, due to the downward growth of hyphae, as in *Fomes* in general. When dry, the pileus decurves strongly.

P. zonalis is usually a small species, not exceeding two inches as a rule. It is permanently wood coloured with red-brown zones, usually strongly concentrically sulcate, and often radially sulcate also, so that the surface is decussately marked. The pore surface is livid or purple-grey, the colour often extending inwards for a short distance. The colour does not "fade out" above; it never was there. The upper surface is glabrous, and when old a thin superficial layer becomes cartilaginous, sometimes over the whole surface, sometimes in concentric bands. The pileus decurves strongly on drying.

The Eastern "*F. lignosus*" is parasitic, while *P. zonalis* is, in Ceylon, a ubiquitous saprophyte. Consequently it has been necessary, in the course of pathological work, to provide the planter with some means of distinguishing between the two, in order to prevent useless expenditure which might be incurred in attempting to exterminate the harmless *P. zonalis*. For that purpose it has, in general, sufficed to demonstrate to the planter that "*F. lignosus*" when broken across shows two colours, the white context and the sharply contrasted red-brown pores, while *P. zonalis* is white throughout, except for the livid coloration extending inwards from the pore surface.

This distinction, however, breaks down for one form of *P. zonalis*, in which the pore surface has, at first, a livid bloom, but the tubes are red-brown, the pore surface being red-brown with age. The red-brown colour usually disappears internally so that the pores are not sharply defined by their colour from the context. The upper surface of the pileus may be more deeply

coloured than in the normal form, and its upper layer is more strongly cartilaginous. This form was named *P. cartilagineus* by Berkeley, but I would prefer to regard it as a variety of *P. zonalis*. For the evidence for this determination of *P. cartilagineus* as *P. zonalis* and not as *P. durus*, see *Preliminary List of Ceylon Polypori*, p. 95. Berkeley's description of *P. cartilagineus* cannot apply to *P. durus*.

Returning to the main line of the subject, we have now to consider *P. micromegas*, *P. microporus*, and the true *F. lignosus*.

The description of *P. micromegas* was first published by Montagne in *Ann. Sci. Nat.* 1842, not in Ramon de la Sagra, *Histoire, etc., de l'Ile de Cuba*, as usually cited. Montagne (*loc. cit.*) explained that he published there, because the French edition of Ramon de la Sagra's History, which had been printed, could not be published until the Spanish edition had appeared. Thus Montagne, in publishing *P. micromegas*, was able to cite a reference to a book which did not appear until three years later. His description is as follows:

"*Polyporus* (*Apus*, *Perennis*) *micromegas* Montag. (*loc. cit.* p. 423, tab. XVII, fig. 5): minimus, pileo suberoso-lignoso tenui dimidiato sessili convexo-pulvinato, ob villum appressum glabrato, zonis omnino angustissimis subimbricatis, concentrice scalari-sulcato, sulcis flexuosis, margine deflexo acuto vel obtuso, subtus plano aut concavo, contextu floccoso porisque pro ratione praelongis confluenti-stratosis minutissimis (nisi oculo armato) inconspicuis, in plano obtusis pallidis intus et ore albovelatis."

In Herb. Montagne in Herb. Paris, in the cover of *P. micromegas*, there is a sheet bearing two specimens, marked "*P. micromegas* Mont. Cuba," in which the pores are large enough to be visible with the naked eye; these may be a different species from the others, unless it should prove, from collections from the type locality, that the size of the pores varies. Another sheet, also bearing two specimens, is marked "*P. micromegas* Mont. Cuba *ex* Ramon de la Sagra," and is probably the type: these are much bored by insects and unsatisfactory. But there is another collection, "Crypt. Guyan no. 358, Leprieur, coll. no. 590," apparently the same as the second sheet, which provides adequate material.

In general, the specimens are orbicular, about a centimetre in diameter, laterally attached, slightly pseudo-stalked, with the pore surface margined behind. The surface of the pileus is glabrous and almost smooth. The upper surface is slightly convexo-pulvinate, almost flat, and the pore surface plane. The pileus does not curl up on drying; the margin slopes abruptly but is not incurved. The flesh is white and thin, and the stratum

of pores is embedded in the pileus, after the fashion of *F. ochroleucus* though not to such a marked degree as in the latter. The colour of the pores does not fade off internally. One of the two specimens in the type is larger, about 2·5 × 1 cm., concave, and dorsally attached: this is apparently a distorted specimen, owing its shape to some irregularity of the substratum, but it provided several of the details in Montagne's description, *e.g.* "subtus...concavo."

P. micromegas is not *P. zonalis* nor the Eastern "*F. lignosus*." The specimens are small, but there is no reason to suppose that they are merely dwarf examples of a larger species. There are many species of *Polypori* in the tropics which are normally small, *e.g. F. atro-albus*.

P. microporus seems to have been the subject of confusion from its debut. Swartz collected it in Jamaica, and in his *Nova Genera et Species Plantarum seu Prodromus*, p. 149, he identified it with *Poria*, no. 4, of Browne's *Civil and Natural History of Jamaica* (1789), an identification which was copied by Fries. But Browne's *Poria*, no. 4, was described by that author as "the thick black *Poria* with very small holes," and compared by him to Micheli, T. 61, fig. 1, *i.e.* to *F. igniarius*. Hence it does not appear likely that it was *P. microporus*.

Swartz described his *P. microporus* in *Fl. Ind. Occ.* p. 1925, as "Boletus, acaulis, difformis, reflexus, inaequalis durus; poris impalpabilibus pallidis. *Prodr.* p. 149. Habitat in truncis arborum *Jamaicae montosae. Pileus* sessilis, difformis (subinde 2–3 accreti,) subexplanatus, resupinus, marginibus reflexis acutis undulatis: supra inaequalis rugosus, versus marginem laevis, colore pallidus, rigidissimus; inferne (situ plerumque superne) aequalis: *Poris* pallidis l. pallide fuscis, nudo oculo minime distinguendis, ope lentis magnitudine inaequalibus, angulatis teretibusve margine acutis. *Tubuli* 3 lin. longi, albidi, capillares, tenuissimi. *Substantia* fungi dura, sublignoso-suberosa, albescens."

Swartz sent specimens to Fries, who included it in *Systema*, 1 (1821), p. 376, as "*P. microporus*, durus, pileo effuso-reflexo rugoso pallido, poris pallidis fuscisve. Difformis rigidissimus, marginibus (*sic*) reflexis undulatis, intus albescens. Pori nudo oculo non distinguendi, sub lente inaequales, angulati, acuti." The foregoing details appear to have been summarised from Swartz's description, but in *Elenchus fungorum*, 1 (1828), p. 111, Fries wrote, "*P. microporus, loc. cit.* Revera ex hac sectione [*i.e.* Perennes], sed tenuis. Pileus glaber, laevis, pallidus (*v.s.* spec. Swartziana)."

The British Museum also had a specimen from Swartz, and this was described by Berkeley (*Fungi Brit. Mus.* p. 375, tab. x,

fig. 6) as "*Polyporus microporus* Fr. Pileo lignoso effuso-reflexo rugoso glabro pallido intus albido, poris minimis acutis pallidis fuscescentibus. *Boletus microporus* Swartz. *Fl. Ind. Occ.* p. 1925. Jamaica, Swartz. Herb. Brit. Mus. Pileus 2–3 inches broad, widely effused behind; margin free, reflexed, waved, rugose, unequal, rigid, pallid, wood-coloured, zoned, very obscurely silky. Substance hard, pallid; margin very acute. Tubes very slender, stratose, orifices very minute*, nearly invisible to the naked eye, at first wood-coloured, then pale gilvous, at length, according to Fries, brown, angular, or subrotund; dissepiments very thin, acute. This species resembles in many respects *Polyporus Auberianus* Mont., as the foregoing (*i.e. P. zonalis* Berk.) does *P. micromegas* Mont. It is allied to *P. ulmarius*. Fries describes this species as zoneless, but the specimen in the British Museum from Swartz is very evidently zoned. *P. Auberianus* also is sometimes without zones or furrows; it differs so much in its large size and free development that from the inspection of a single specimen only of either species, it would be rash to give too decided opinion as to their identity."

The specimen figured by Berkeley is still in Herb. British Museum. The illustration is a good representation of the specimen, but, as noted by Saccardo (*Sylloge*), the pore surface is represented as violet-grey (violaceo-fuscus, Saccardo), not wood-coloured, as described. The colour of the pore surface in this figure is exactly the same as that correctly figured for *P. zonalis* on the same plate. Did Berkeley's artist fail him or did the printer economise by making both the same colour?

The British Museum specimen is resupinate, with a free dimidiate edge about 1 cm. broad. The free edge is feebly concentrically sulcate (in this instance Berkeley's "zoned" means sulcate), with a dull mat or feebly silky surface. The section shows the pores apparently stratose, as in Berkeley's figure, but without cutting the specimen it is doubtful whether this appearance is not due to irregular fracturing of the pore layer. The pore surface is brown, and in section the brown colour ceases irregularly before reaching the context. The inner part of the pores is normally white; the colour has not "faded out." This is a poor specimen, the free pileus not being sufficiently developed, but the section of the pores shows that it is not the rubber root disease fungus. Berkeley's reference to "large size" no doubt refers to *P. Auberianus*; his specimen of *P. microporus* is small.

Lloyd (*loc. cit.*) refers to the British Museum specimen as the type. The type, however, of *P. microporus* (Sw.) Fries should be in Fries's herbarium.

* In the figure they are too strongly expressed.

But although the British Museum specimen described by Berkeley is poor, there are several others, collected more recently in Jamaica by Elliott, which appear to be the same species. These are quite distinct from *P. zonalis* or *P. micromegas*, but they do to some extent resemble the Eastern "*F. lignosus*." They differ from the latter in the thinner pileus, with a more acute margin, and even and very silky surface. Apparently they are more rigid when fresh, and do not curl up on drying. The Eastern "*F. lignosus*" curls up on drying, or, if prevented from curling, the pore layer splits. One piece of Elliott's collection in Herb. British Museum is curled up, but it is apparently a totally resupinate piece.

It is worthy of note that, judging from the literature, *F. lignosus* is not known as the cause of root disease in the West Indies.

The true *F. lignosus* was described by Klotzsch, as *Polyporus*, in a paper entitled "Fungi exotici e collectionibus Britannorum," in *Linnaea*, VIII (1833), p. 485, the description being:

"*P.* (*Apus*, *Bienn. Subsuberos.*) *lignosus*. Flavidus, pileo carnoso suberoso zonato ruguloso glabro, basim versus crassiore, poris violaceis minutissimis, basi decurrentibus. Substantia post siccationem lignea tenax. Pileus 4–6 unc. latus, 3 unc. long., superne ut a solutione Curcumae tinctus, zonatus rugulosus, 4–5 lin. crassus. Pori minutissimi, extus intusque violacei, aequales."

I have not seen the type specimen. Although the fungi were from British collections, Klotzsch deposited his types in "Herbario regio Berolinensi." Of the sixty-two localities cited by him, thirty-four are in North America, nineteen in Mauritius, seven in India, and two in St Vincent. But Klotzsch omitted to give a locality in the case of two species, one of which, unfortunately, is *F. lignosus*. The statement that the type of *F. lignosus* came from Mauritius was made by Fries.

In *Ann. Nat. Hist.* III (1839), pp. 375–401, Berkeley published translations of Klotzsch's descriptions in a paper entitled "Descriptions of Exotic Fungi in the collection of Sir W. J. Hooker from Memoirs and Notes of J. F. Klotzsch with additions and corrections." But he did not include the description of *Polyporus lignosus*, or make any reference to it. This omission raises several queries. Was *Fomes lignosus* not one of Hooker's specimens, or had Berkeley a suspicion that the specimen was not a new species?

Fries placed *P. lignosus* in his section "6. Lignosi, pileo primitus duro lignoso exsucco, crusta tenui subvernicea glabra l. glabrescente texto, basi subeffuso, poris non stratosis. *Perennantes* (non putrescentes) *sed non stratosi, prioribus magis applanati l. effuso-reflexi.*" His description of *P. lignosus* in *Epicrisis*, p. 471 is:

"? *P. lignosus*, pileo e carnoso? suberoso-lignoso applanato *concentrice sulcato*, primo villoso rugoso pallido, adulto glabrato flavido, intus pallido, *poris longis minimis* tenuissimis stipatis interne pallidis, *versus superficiem fuscis*. Klotzsch! in *Linn.* VIII, p. 285. Insula Mauritii. Insignis, potius inter Subsuberos inserendus; licet cutis hujus gregis et siccus sit ligneus tenax; vegetus (quum siccitate incurvetur) omnino videtur carnosus, et quidem *P. cubensi* et *P. strumoso* intermedius. Basis decurrens. Pori, ex Klotzsch, extus intusque violacei; sed in nostro ad medium pallidi, carne concolores."

The italics in the foregoing quotations are as published by Fries. Apparently Fries had a specimen from Klotzsch.

Perusal of these descriptions only leads to further doubt. Fries emphasised the fact that the pileus was "concentrice sulcato"; that is not, as a rule, a marked feature of the rubber root disease fungus, but it may be of *P. zonalis*, which owes its name to the deeply furrowed specimen described by Berkeley. Again, Klotzsch stated that the pores were "extus intusque violacei," which is not true for the rubber root disease fungus but is true for *P. zonalis*, if "intus" is not taken to extend to the base of the pores; and Fries's description of the pores as "ad medium pallidi, carne concolores" and "interne pallidis, *versus superficiem fuscis*," the latter emphasised by him, fits *P. zonalis*, not the rubber root disease fungus. One would take both these descriptions as referring to *P. zonalis*, were it not for the colour given for the pileus. Klotzsch described the pileus as yellow, as if dyed with a decoction of turmeric, a description which does not fit either *P. zonalis* or the rubber root disease fungus.

Recently, Spegazzini recorded *F. lignosus* from the Argentine with a brief re-description (*Bol. Acad. nac. Ciencias en Cordoba*, XXVIII (1926), p. 357). He stated that it occurs on fallen branches, and that, according to Bresadola, his specimens correspond exactly with the type and are difficult to separate from *F. ulmarius*. The pileus is "coriaceo-sublignose," relatively thin (5–10 mm.), the colour of chamois leather, with some concentric furrows and many fine radiating wrinkles; the context is very pale ochraceous; the hymenium is "cinereo-umbrino," with the tubes ochraceous in section; the tubes are short, 1–4 mm. long.

It is difficult to see, in the rubber root disease fungus of the East, the close resemblance to *F. ulmarius*, which is emphasised for *F. lignosus* by Fries and Bresadola, and for *P. microporus* by Berkeley. Further the "*F. lignosus*" of the East does not grow on fallen branches, has not a unicolorous upper surface, and has a white context. It is evident that Spegazzini's species is not the same.

On the other hand, allowing for the fading of colours in the old herbarium specimens, Klotzsch's, Fries's and Spegazzini's descriptions of *F. lignosus* Klotzsch would agree fairly well with *P. microporus* Fr., which apparently is a species with a pileus uniformly coloured, yellow or bright yellow on the upper surface when fresh. It would appear a feasible suggestion that Klotzsch's specimen was not from Mauritius, but from the West Indies.

Accepting Lloyd's identification of *F. lignosus* proper with *P. microporus*, and Bresadola's identification of South American specimens with the type of *F. lignosus*, I would suggest the following solution—that the type of *F. lignosus* Klotzsch was a West Indian specimen, not one from Mauritius, and that it is the same species as *P. microporus*, which is also a West Indian species, but that it is not the same as the rubber root disease fungus of Ceylon and Malaya. I am unable to visit Berlin and check this suggestion by inspection of Klotzsch's type specimen.

In any case, the rubber root disease fungus of the East is not *P. microporus*, and, if Lloyd's identification of the latter with the real *F. lignosus* Klotzsch is correct, it cannot be *F. lignosus*. The conclusion would appear to be that none of the names which have been applied to the rubber root disease fungus is the right one, and that it is really an unnamed species.

NEW OR RARE BRITISH DISCOMYCETAE.

By Carleton Rea, B.C.L., M.A., Hon. Member British Mycological Society, etc.

Since the publication of my last paper on this subject in the *Transactions* of this Society for 1922, many additions have been made to the British list. Some of these species are of frequent occurrence and an accurate diagnosis will enable the student in this branch of mycology to identify them elsewhere. My hearty thanks are accorded to the different collectors whose names are recorded in connection with each species.

Mitrophora fusca (Pers.) Lév. Boud. Icon. Myc. II, t. 217, IV, 113.

Pileus 2–3 cm. high, 1·5–3 cm. wide at base, *tawny ochre*, conical, oblong, obtuse, free from the stem for half its length; longitudinal ribs *concolorous*, fairly thick, often anastomosing, enclosing more or less numerous, square secondary pits; underside *furfuraceous*. Stem 3–8 cm. high, 5–12 mm. thick, *concolorous, paler*, cylindrical, or slightly attenuated at the base, furfuraceous, often longitudinally furrowed. Asci cylindrical, flexuose at the slightly attenuated base, 260–300 × 11–22 μ.

Spores hyaline, elliptical, 19–22 × 10–12μ. Paraphyses hyaline, branched, branches often thickened at the apex, 16–19μ in diam., contents granular, 250–290 × 11–12μ.

Moist ground in wood, Devil's Den, Worcestershire, May 5th, 1922, Miss Violet Rea. Easily distinguished from *Mitrophora hybrida* (Sow.) Boud. by its *smaller size, paler colour* and *smaller asci and spores.*

Helvella cinerea (Bres.) Rea. Bres. Fung. Trid. II, 41, t. 147, fig. 1, as *Helvella sulcata* Afz. var. *cinerea* Bres.

Pileus 1–3 cm. wide, *greyish cinereous, becoming black*, two to three lobed, reflexed, adnate to the stem, *pruinose*; underside *white*, sometimes veined. Stem 1–3 cm. high, 4–10 mm. thick, *white, becoming cinereous*, equal, or slightly attenuated at the base, stuffed, deeply furrowed, ribs thick. Asci cylindrical, attenuated at the base, 250–275 × 12–14μ. Spores hyaline, elliptical, 16–18 × 10–11μ, with a large central gutta. Paraphyses *hyaline*, branched, septate, apex clavate, 4–5μ in diam., 255–275 × 3μ.

On the ground, Burnham Beeches, Bucks, November 11th, 1923, Mr W. D. Buckley, and Wyre Forest, Worcestershire, September 28th, 1927, C. R.

A distinct species differing from *Helvella sulcata* Afz. in its *much smaller size, the white stem and underside of the pileus and the smaller asci.*

Discina leucoxantha Bres. Bres. Fung. Trid. I, 42, t. 44, as *Peziza* (*Discina*) *leucoxantha* Bres. Boud. Icon. Myc. II, t. 253, IV, 136.

Ascophores 4–7 cm. wide, disc *bright egg-yellow*, fleshy, cup-shaped, then expanded and revolute at the margin, smooth, then rugulose; externally *white, becoming yellowish with age*, smooth. Stem *white, or yellowish*, short, somewhat thick, becoming furrowed with age. Flesh *whitish, ochraceous under the hymenium*. Asci cylindrical, flexuose and attenuated at the base, 400–430 × 20–24μ. Spores hyaline, *minutely verrucose*, boat-shaped, *with a truncate, concave appendage at each end*, 32–36 × 12–15μ, with a large central gutta accompanied with more or less numerous guttulae. Paraphyses clavate, branched below, septate, filled with ochraceous granules upwards.

In sandy soil in coniferous woods, especially larch. Spring.

var. **fulvescens** Rea.

Differs from the type in the *deep, fulvous colour of the disc and in its habitat.* Amongst grass, twenty yards distant from an old beech stump, near Perth, Mr J. Menzies, May 12th, 1924. The type has not been recorded for Britain, but the very characteristic,

rough spores with truncate, concave appendages, 31–37 × 14–15μ, leave no doubt as to its identity.

Aleuria ollaris (Pers.) Rea. Bres. Fung. Trid. II, 77, t. 192, fig. 1.

Ascophores 5–30 mm. wide, disc *pale yellow or citron-yellow*, becoming somewhat fuscous with age, hemispherical, then expanded and concave, finally revolute at the margin, sessile or slightly rooting; externally *white*, furfuraceous. Flesh *concolorous*, pseudoparenchymatous. Smell unpleasant, like that of *Aleuria vesiculosa*. Asci cylindrical, shortly stipitate, 220–270 × 12–14μ. Spores hyaline, *epispore becoming blue with iodine*, elliptical, 13–15 × 8–9μ ("16–20 × 8–10μ" sec. Bres.). Paraphyses slender, equal or slightly enlarged upwards, 270–280 × 4μ, septate; apex 4–6μ in diam., filled with yellowish granules.

Flower-pots in greenhouses, Marlborough, Wilts, November 6th, 1922, Mr A. G. Lowndes.

Aleuria subcitrina Bres. Boud. Icon. Myc. II, t. 271, IV, 148.

Ascophores 1–2 cm. wide, *entirely lurid yellow, then lemon-yellow*, concave, subhemispherical, disc sometimes umbilicate, then expanded and reflexed at the margin, smooth, then rugulose, sessile; externally glabrous. Flesh *paler*. Asci cylindrical, slightly attenuated at the base, 310–350 × 15–16μ. Spores hyaline, elliptical, 18–20 × 10–11μ. Paraphyses *yellowish*, simple, slightly enlarged upwards and curved, 315–360 × 3μ, contents granular, septate.

Old apple pulp refuse, Ipplepen, Devon, September 16th, 1923, Miss J. C. Eyre.

Aleuria reperta Boud. Bull. Soc. Myc. Fr. X (1894), 64, t. II, fig. 3.

Sporophore 1–1·5 cm. wide, *olivaceous green*; disc convex, then somewhat plane, marginate, externally pruinose. Stem *concolorous*, short, thick, minutely villose, sometimes sulcate. Flesh *concolorous*, thick. Asci olivaceous, cylindrical, slightly attenuated downwards, 280–305 × 13–14μ ("250 × 13μ" sec. Boud.), operculate, *turning blue at the apex with iodine*. Spores *olivaceous*, oblong, *very pointed at both ends*, 22–27 × 8μ, very minutely verrucose. Paraphyses hyaline, contents minutely granular, cylindrical or slightly thickened upwards, apex 5–6μ in diam., simple, 285–315 × 3–4μ, septate.

On rotten, decorticated wood, Mickleham, Surrey, April 10th, 1927, Rev. J. H. Bloom.

The spores and asci in this single specimen were uncoloured and the former were smooth and had multi-granular contents, but these very probably would become olivaceous and minutely

verrucose with age, as these qualities are often developed only at complete maturity. The large, acutely pointed spores characterise this rare species which Boudier found once only, in September, 1868, on rotten wood of *Populus nigra*.

Aleuria umbrina Boud. var. **assimilata** (Karst.) Boud. Karst. Myc. Fenn. I, 53.

Differs from the type in its much *smaller size*, 1–2 cm. wide, *dirty whitish colour becoming fuscous on the disc, the incised or crenate margin and the smaller spores*, 13–17 × 7–9μ. Burnham Beeches, Bucks, October 20th, 1925, Mr A. A. Pearson.

Aleuria Emileia Cke. Boud. Icon. Myc. II, t. 280, IV, 153.

Ascophores 3–10 cm. wide, disc *tawny cinnamon, often somewhat yellowish at the margin*, undulate, cup-shaped, sessile, margin more or less irregularly sinuate or lobed; externally *tawny, becoming whitish when dry*, slightly tomentose and furfuraceous. Flesh *concolorous, paler*. Asci cylindrical, slightly attenuated at the base, 230–250 × 14–17μ. Spores hyaline, *verrucose*, oblong elliptic, 15–16 × 8–9μ. Paraphyses hyaline or slightly coloured, clavate, 235–255 × 3μ, club 4–6μ in diam., septate, contents granular.

Burnt ground, Virginia Water, Berks, September 29th, 1923.

Galactinia olivacea Boud. Boud. Icon. Myc. II, t. 282, IV, 154.

Ascophores 3–5 cm. and more wide, *fuscous olivaceous, often tinged reddish when young*, cup-shaped, sessile, margin minutely toothed, externally furfuraceous especially near the margin. Flesh *concolorous, becoming whitish when dry*, thin. Asci hyaline, becoming slightly fuscous with age, cylindrical, 300–390 × 10–14μ. Spores hyaline, somewhat fuscous with age, *verrucose*, oblong elliptical or subfusiform, 18–20 × 10–11μ, *eguttulate*. Paraphyses hyaline or slightly coloured, slender, slightly thickened upwards, 320–410 × 2μ, apex 4μ in diam., septate, contents nebulose.

On the ground, Weston Firs, Wyre Forest, Shropshire, October 12th, 1922.

Galactinia Michelii Boud. Boud. Icon. Myc. II, t. 286, IV, 157.

Ascophores 2·5–5 cm. wide, disc *purple*, cup-shaped, then expanded and somewhat undulate, sessile; externally *tawny*, minutely furfuraceous especially near the margin. Flesh *golden tawny*, milk *whitish*. Asci hyaline, becoming slightly yellowish with age, cylindrical, 240–260 × 13–15μ. Spores hyaline, *often tinged with yellow when mature, minutely verrucose*, 15–17 × 9–10μ, with two large guttae. Paraphyses *yellowish*, slender, slightly enlarged upwards, simple or branched at the base, 240–265 × 3–4μ, apex 5–6μ in diam., septate.

Amongst conifer needles, Bricket Wood, Watford, Herts, October 11th, 1925, Miss C. A. Cooper.

Galactinia Sarrazinii Boud. Boud. Icon. Myc. II, t. 291, IV, 160.

Ascophores 3–5 cm. or more wide, cespitose, disc *tawny fuliginous*, cup-shaped, often irregular and deformed by mutual pressure, sessile, margin irregularly crenate; externally *white bluish grey or lead-colour at the base, suffused with the colour of the disc in the upper half*, slightly furfuraceous. Flesh *cinereous*, thin. Asci cylindrical, much attenuated at the base, 260–275 × 9–10μ. Spores hyaline, *very minutely verrucose*, elliptical, 11–12 × 5–6μ, 2-guttulate. Paraphyses filled with yellowish granules, slender, slightly thickened at the apex, 5–6μ in diam., simple, 260–275 × 3μ, straight or slightly curved, not or sparsely septate.

Burnt ground, Tring Park, Hertfordshire, September 22nd, 1925, Mr E. J. H. Corner; charcoal heaps, Hawkbatch Wood, Wyre Forest, Worcestershire, October 2nd, 1927.

Galactinia proteana Boud. Boud. Icon. Myc. II, t. 293, IV, 161.

Ascophores 3–6 cm. wide, *white, or greenish white, often irregularly tinged with rose colour, sometimes slightly ochraceous*, cup-shaped, then expanded, sessile; externally glabrous or slightly furfuraceous towards the margin. Asci cylindrical, slightly attenuated at the base, 210–225 × 10μ. Spores hyaline, *minutely verrucose*, elliptical, 12–13 × 5–6μ, 2-guttulate. Paraphyses slender, equal, or slightly enlarged upwards, 220–240 × 2–3μ, apex 4–7μ in diam., septate.

Charcoal heap under yews and beeches, Medmenham Abbey, Bucks, September 30th, 1927, Mr E. J. H. Corner; under beeches Woollashall, Worcestershire, 5th September, 1928.

Galactinia badiofusca Boud. Boud. Icon. Myc. II, t. 297, IV, 164.

Ascophores 5–15 mm. wide, *fuscous bay*, cup-shaped, then expanded, sessile; margin minutely crenulate; externally *paler*, granular. Flesh *fuscous*, milk *bluish white*. Asci becoming slightly fuscous with age, cylindrical, scarcely attenuated at the base, 275–310 × 12–15μ. Spores hyaline, *densely verrucose*, elliptical, 13–16 × 7–8μ, with a large central gutta, rarely 2–3-guttulate. Paraphyses hyaline, slender, slightly thickened upwards, 265–305 × 3–4μ, apex often densely covered with the fuscous, gelatinous epithecium, 5–6μ in diam., septate.

On the ground, Benthall, Salop, October 1st, 1915, and October 4th, 1924.

Pustularia Gaillardiana Boud. Boud. Icon. Myc. II, t. 339, IV, 189.

Ascophores 4–8 mm. wide, *greyish ochre*, always cup-shaped, shortly stipitate or subsessile, margin slightly crenulate; ex-

ternally minutely granular, tomentose. Asci cylindrical, attenuated at the base, 280–320 × 17–18 μ. Spores hyaline, oblong elliptic, 23–26 × 12–15 μ, with two large guttae. Paraphyses hyaline, slender, slightly thickened at the apex, 285–325 × 2–3 μ, simple or branched, septate.

Bare soil, Symond's Yat, Gloucestershire, September 18th, 1925.

Pustularia scotica Rea*.

Ascophores 5–15 mm. wide, *dark grey, becoming sometimes tinged with fuscous*, cup-shaped, sessile; margin *white*, minutely crenulate. Flesh *whitish*, thin. Asci cylindrical, slightly attenuated downwards, 280–290 × 14–20 μ. Spores hyaline, elliptical, 22–23 × 12–13 μ, with two large guttae. Paraphyses hyaline, slender, slightly enlarged at the apex, 300–320 × 3–4 μ, apex 5–6 μ in diam. septate.

On clay soil, near Perth, October 9th, 1909, Mr J. Menzies.

Lachnea Eichleri Bres. (= *Tricharia Eichleri* Bres. sec. Boud.) Bres. Fung. Polon. Ann. Myc. I (1903), 119.

Ascophores, 2–4 mm. wide, disc *pallid*, concave, sessile; externally *fuscous*, densely strigose with *tawny bay* setae, setae *brown, hyaline towards the apex*, 95–200 × 11–24 μ, apex acute, 4–5 μ in diam., base subbulbous, 1–2-septate, thick-walled. Asci cylindrical, attenuated at the base, 190–205 × 10–12 μ. Spores hyaline, *smooth*, elliptical, 12–15 × 8–9 μ, with a guttula at each end. Paraphyses hyaline, scarcely thicker at the apex, 195–210 × 2–3 μ, apex 4 μ in diam.

Burnt soil, near Cambridge, November 12th, 1923, Mr F. T. Brooks.

Lamprospora carbonicola Boud. Boud. Icon. Myc. II, t. 401, IV, 227.

Ascophores 1·5–3 mm. wide, *orange-red*, hemispherical, then expanded and convex, sessile, margin triangularly dentate; externally paler. Flesh *concolorous, paler*. Asci clavate, attenuated at the base, 220–245 × 18–20 μ. Spores hyaline, *smooth*, globose, 13–15 μ, with a large central gutta. Paraphyses *orange-red*, slender, slightly enlarged upwards, simple or branched from the base, 225–250 × 6–8 μ, septate.

Amongst moss on burnt ground, Acton Scott, Salop, October 5th, 1924, Miss Violet Rea.

* *Pustularia scotica* Rea.

Ascomata 5–15 mm. lata, *griseo-cinerea, saepe fuscescens*, cupularis, sessilia, margineque *albo*, minutissime crenulato; substantia *albida*, tenuis. Asci cylindracei, deorsum sensim attenuati, 280–290 × 14–20 μ. Sporae hyalinae, ellipticae, 22–23 × 12–13 μ, crasse biguttulatae. Paraphyses hyalinae, filiformes, 300–320 × 3–4 μ, ad apicem paululum incrassatae, 5–6 μ spissae, septatae. Autumno, ad terram argilaceam, prope Perth.

Ascophanus Bresadolae Boud. (= *Humaria aurantiaca* Bres. Bres. Fung. Trid. II, 80, t. 194, fig. 2).

Ascophores 1–2 mm. wide, *densely gregarious*, *bright orange-red*, subglobose, then expanded and convex, scarcely marginate, sessile. Flesh *concolorous*, *paler*, pseudoparenchymatous, polygonal cells, 12–18μ in diam. Asci cylindrical, attenuated downwards, 210–240 × 10–12μ ("140–180 × 10–14" sec. Bres.). Spores hyaline, elliptical, 12–15 × 7–8μ, eguttulate. Paraphyses *filled with yellow granules*, slender, somewhat enlarged at the apex, 215–245 × 2μ, apex 3–4μ in diam., straight or curved at the apex, often branched, septate.

On rabbit dung, Blackdown, 1000 ft., Mendip Hills, Somerset, January 3rd, 1923, Mr F. T. Brooks.

Pyronema glaucum Boud. Boud. Icon. Myc. II, t. 420, IV, 239.

Ascophores 1–1·5 mm. wide, *greenish white*, *gregarious*, often confluent, sessile. Asci cylindrical, slightly attenuated downwards, 180–205 × 12μ. Spores hyaline, broadly elliptical, 14–15 × 10–11μ. Paraphyses hyaline, cylindric-clavate, 180–205 × 7–8μ at apex, septate.

On partially sterilised earth in greenhouse, Harpenden, Herts, March 26th, 1912, Mr F. T. Brooks; on old charcoal heaps, Wyre Forest, Worcestershire, July 30th, 1925, C. R.

Pachydisca belonea Cr. Cr. Fl. Fin. 48.

Ascophores 0·5 mm. wide, *white*, convex, sessile, papillate with the apices of the asci under a lens; externally glabrous. Asci cylindrical, attenuated at the base, 120–135 × 12μ, foramen marginate. Spores hyaline, oblong, often pointed at one end, 14–20 × 5–6μ, 3–5 guttulate. Paraphyses hyaline, slender, 120–130 × 2μ, apex subclavate, 3μ in diam.

On and amongst *Polytrichum*, Epping Forest, Essex, October 13th, 1923, Mr A. A. Pearson.

Calycella ochracea Boud. Boud. Icon. Myc. III, t. 442, IV, 255.

Ascophores 1–2 mm. or more wide, gregarious, *ochraceous*, *becoming tawny*, cup-shaped, stipitate, then expanded and undulate at the margin; externally *paler*, glabrous. Asci clavate, 112–125 × 8–10μ. Spores hyaline, fusiform or fusiform-clavate, 6–10 × 3–4μ. Paraphyses filled with yellowish granules, slender, slightly thickened upwards, simple or branched, 113–126 × 1·5–2μ, septate.

On decorticated wood, Weybridge, Surrey, February 22nd, 1922, Mr A. A. Pearson; on *Corylus* stump, Middleyards Coppice, Bransford, Worcestershire, February 5th, 1925, C. R.

Helotium Cuniculi Boud. Bull. Soc. Myc. Fr. XIII (1897), 16, t. 3, fig. 4.

Ascophores 2–3 mm. wide, disc *deep ochraceous yellow, sometimes somewhat brick colour,* cup-shaped, soon plane; margin *brownish*; externally *ochraceous yellow,* smooth. Stem 2–3 mm. high, *ochraceous,* thick, attenuated downwards. Asci elongate-clavate, 200–210 × 12–14μ. Spores hyaline, oblong-fusiform, 14–18 × 6–8μ, contents granular becoming finally 1-septate. Paraphyses hyaline, slender, incrassated upwards, 200–210 × 4–5μ at apex, septate.

On rabbit dung and bark of fallen tree, Yoxall Lodge Woods, Staffordshire, September 22nd, 1927.

Arachnopeziza nivea Lort. Bull. Soc. Myc. Fr. XXX (1914), 224, t. 12, fig. 3.

Ascophores 0·5–1·2 mm. wide, gregarious, *snow-white, disc becoming finally yellowish,* convex, then expanded, sessile, *seated on a delicate, somewhat dense, flexuose, branched, shining white, arachnoid subiculum*; margin fimbriate with acute, septate, white hairs, 260–280 × 18–20μ. Asci clavate, attenuated downwards, 110–120 × 8–11μ. Spores hyaline, rod-shaped, attenuated at the one end, obtuse at the other, 60–70 × 2–3μ, 6-*septate.* Paraphyses slender, simple or branched, 115–125 × 2–3μ.

On dead fallen branches, Shrawley Wood, Worcestershire, August 29th, 1921, Mr A. A. Pearson; Wyre Forest, Worcestershire, July 25th, 1925, and Crews Hill Wood, Worcestershire, September 27th, 1927.

Micropodia arenula (Alb. & Schwein.) Boud. Boud. Icon. Myc. III, t. 528, IV, 310.

Ascophores 0·2–0·5 mm. wide, *greyish,* urceolate, then cup-shaped, rarely expanded; margin *white.* Stem *dark grey, slightly ochraceous,* short, covered like the exterior of the cup with septate, obtuse, undulate, pale hairs, hyaline at the apex. Asci oblong, often larger at the base, 25–30 × 8–9μ. Spores hyaline, oblong-fusiform, often slightly clavate, rarely slightly curved, 9–10 × 2μ. Paraphyses hyaline, sparse, slender, simple or branched, 25–30 × 2–3μ, obscurely septate.

On dead fronds of *Pteris,* Malvern Hills, Worcestershire, March 24th, 1924 and Wyre Forest, Worcestershire, October 2nd, 1927.

THE IDENTITY OF PHOMA PITYA SACC., PHOMA ABIETINA HART. AND THEIR RELATION TO PHOMOPSIS PSEUDOTSUGAE WILSON*.

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(With Plates XVIII–XXI.)

Introduction.

During the last fifty years there have been numerous references in the literature, both mycological and forestry, to *Phoma pitya* Sacc.† and *Phoma abietina* Hartig (*Fusicoccum abietinum* Prill. & Delacr.) and a considerable number of diseases of conifers have been attributed to these species. Recently a new species closely allied to these, *Phomopsis Pseudotsugae* Wilson, has been described (59, 60, 64) as the cause of a disease of the Douglas fir (*Pseudotsuga Douglasii*) and other conifers in Great Britain. On account of the confusion now existing in the literature as to the identity of the fungi described during the latter half of the last century, the question has arisen of the relation existing between them and the newly described fungus.

History.

Phoma pitya Sacc. was described in 1878 by Saccardo from specimens collected on twigs of *Pinus sylvestris* by P. Magnus in the Botanic Garden at Berlin. The fungus was found on dead twigs and there is no evidence that it was parasitic.

Rostrup in Denmark was the first to associate *Phoma pitya* with disease in conifers. Writing in 1885 (46) he states, "A rather large plantation of *Picea excelsa* (Rottanne) planted in 1882, with four year old trees, had a most distressing appearance because of thousands of withered plants. On numerous plants which I examined there was always found, on the lower part of the stem, partly a little above ground and partly under ground, a portion about two inches long covered with numerous small black fructifications, which by a critical examination

* Grateful acknowledgment is due to Miss E. M. Wakefield, of the Royal Botanic Gardens, Kew, and to Mr J. Ramsbottom of the British Museum, for valuable critical assistance in the manuscript preparation.

† The Greek for pine being πίτυς, Saccardo's incorrect orthography has been corrected. Where an author is quoted directly, the orthography used by him is followed.

after my return home proved to belong to *Phoma pithya*. This species is not hitherto known as a parasite and only its constant association in the same locality with all the dead and diseased plants indicates that it bears some relation to the devastation. The roots of the withered plants were well developed and showed no injury from insects and there was on the whole no cause other than the fungus which appeared to be responsible for the disease."

He gave a further account of the disease on *Pseudotsuga Douglasii* and *Abies pectinata* in 1890 (47) and here states that *Phoma pitya* is identical with *Phoma abietina* Hartig, and lists the disease in his Plantepatologi in 1902 on *Pseudotsuga Douglasii, Abies pectinata, A. balsamea, Picea excelsa, Pinus sylvestris, P. montana, P. Strobus* and *Larix europaea*. He also recorded the fungus from Bornholm in 1906 on *Pseudotsuga Douglasii* and *Pinus Strobus*.

Meanwhile a somewhat similar disease (Pl. XX, figs. 7, 8) had been described in Germany in 1889 on *Abies pectinata* by Hartig (19) who was of the opinion that it was caused by a new species "der Tannenrindenpilz," which he named provisionally *Phoma abietina*. He records the disease from the Bavarian Forest, the Bavarian Alps and the Black Forest, stating that "sehr grossen Schaden anrichtet" in the first named locality. The disease is described in his text-book and in the English translation of this work by Somerville and Marshall Ward (21).

Shortly after Hartig's discovery Prillieux and Delacroix (42) reported the same disease (Pl. XX, figs. 7, 8) from Gerardmer, Vosges, France in 1890 on *Abies pectinata* stating at first that it was due to the fungus *Dothiorella pitya* Sacc., but later (43) giving it the combination *Fusicoccum abietinum* (Hart.) Prill. & Delacr. They regarded their fungus as identical with *Phoma abietina* Hart., upon the examination of a specimen of this fungus sent to them by Hartig. This disease was also described by Mer in 1890 from Gerardmer, and a further detailed account of the effect of the fungus on the silver fir in France was published by him in 1893. He identified the fungus as *P. abietina* Hart. (*F. abietinum* Prill. & Delacr.) Other French accounts of an outbreak of the disease on the silver fir in the Jura in 1907 were given by Henry (23, 24, 25) Prillieux and Maublanc (44), Maublanc (34) and Mer (37). Amongst these authors Mer appears to prefer the original name *Phoma abietina* for the fungus. Prillieux (41) has also published an account of *Fusicoccum abietinum* on *Abies pectinata* in his text-book on plant diseases.

Böhm in 1896 gave an account of the attack of *Phoma abietina* on the Douglas fir in North Germany. His determination of the fungus was verified by P. Magnus and the description given is that of *Fusicoccum abietinum* as quoted from

Saccardo ((51), vol. x). Böhm pointed out that up to that time this fungus had been recorded only on *Abies pectinata*. Böhm's paper was reviewed by Forbes in 1896. The parasites *P. abietina* (*F. abietinum*) on *Abies pectinata*, and *P. pitya* on *Pseudotsuga Douglasii* were discussed by Tubeuf in his text-book published in 1895 and translated into English by Smith in 1897. Tubeuf drew attention to Rostrup's description of *P. pitya* quoted above and mentioned that it closely resembled *P. abietina*. In a footnote in the English translation Smith suggested that there has been some confusion between the two species. Allescher (2) described both *P. pitya* and *F. abietinum* in Rabenhorst's *Kryptogamen-Flora*. He gave *Dothiorella pitya* Prill. & Delacr. nec Sacc., and *Phoma abietina* Hart. as synonyms for *F. abietinum* Prill. & Delacr.

Meanwhile Somerville in 1898 had identified as "almost certainly *Phoma pitya* Sacc." a fungus found on a diseased Douglas fir in Scotland by Leven (30). The same fungus was recorded by Farquharson (13) on this host near Aberdeen.

Schwappach in 1909 recorded "*Phoma pythia* (*P. abietina*)" as the cause of a disease of *Pseudotsuga Douglasii* and *Picea sitchensis* in Eberswalde, North Germany, and stated that Böhm (6) had already discussed the disease from a mycological standpoint. Lindau in 1908 in Sorauer's text-book referred to *Phoma pitya* as the cause of the "Einschnürungskrankheit" of the Douglas fir, and to *Fusicoccum abietinum* as the cause of a disease on the silver fir designated by the same term.

Lind in 1913 in his account of Rostrup's herbarium described "*Phomopsis pithya* (Sacc.) Lind," and gave as synonyms—"*Phoma pithya* Sacc., *Phoma abietina* Hartig, *Fusicoccum abietinum* Prill. et Del." He referred to it as a true parasite and recorded it on *Abies balsamea, A. pectinata, A. concolor, Picea excelsa, Pinus sylvestris, P. montana, P. Strobus, Pseudotsuga Douglasii* and *Juniperus virginiana*. Grove (16) stated that the fungus which Lind called *Phomopsis pitya* (Sacc.) was identical with *Phoma abietina* Hart. but not with *Phoma pitya* Sacc. (although Lind himself gives the latter as a synonym), and that the correct name for the species should be *Phomopsis abietina* (Hart.) Grove. In 1921 he further stated that *Ph. abietina* was very probably polymorphic having a *Phomopsis* state, a *Fusicoccum* state, a *Dothiorella* state, and probably a *Sclerophoma* state. He regarded the species as "a decided parasite, doing great harm to numerous species of Coniferae on the Continent" and suggested that it might become equally dangerous in the Scottish forests.

Recently in 1920 a disease of the terminals of the side branches of Douglas fir was reported by the Biologische Reichsanstalt (3)

as occurring at Stettin, which was regarded as being caused by *Phoma pitya*, and Hausrath (22) in 1921–2, recorded the appearance of a disease of the branches among 25–30 year old Douglas fir caused by *P. abietina* in the forests at Oberweiler and Bruchsal. De Koning ((29) Figs. 82, 83) in Holland has described a disease of the Douglas fir which is referred to by the name "Insnoeringsziekte" and states that it is caused by "*Phoma pytia* Sacc.," which he remarks, "is the most noteworthy species of the genus *Phoma* that is harmful to woody plants." He observed it in many places in Holland. He also mentioned the disease on the silver fir caused by *P. abietina*. Neger (38) gave a short description of the "Einschnürungskrankheiten" caused by *Phoma abietina* on *Abies pectinata* and by *P. pitya* on *Pseudotsuga Douglasii* and *Pinus Strobus*. He regarded *Phoma pitya* as a parasite of juvenile stock of two or three year old plants. He figured ((38), p. 174, Abb. 134) young plants of *Pinus Strobus* affected with *Phoma pitya*, and a pycnidium and spores of what he considered to be Saccardo's fungus.

Doidge (11) in 1924 in a preliminary list of the plant diseases of South Africa included *Phoma abietina* on *Pinus* sp. from the Transvaal and from the Orange Free State, and on *Cupressus* sp. from the Transvaal. Stevenson in 1926 quoted *Fusicoccum abietinum* as occurring on *Abies Veitchii* (4) in Ohio, United States of America.

The most recently described European disease of the Douglas fir (Pl. XXI, figs. 11, 12, 13, 14) closely related to *Phoma pitya* and *P. abietina* and attributed to *Phomopsis Pseudotsugae* was described by the senior author in 1925 (59, 64). This fungus is listed by Hickel (26) as synonymous with "*Phoma pythia* (*Ph. abietina*)" among the diseases of the Douglas fir in Europe. Fabricius in 1926 recorded the attack of *P. pitya* on the leading shoots of the Douglas fir in Denmark but he considers that the fungus is generally saprophytic and often associated with frost damage. He refers to the closely related fungus *Ph. Pseudotsugae* and states that this has not been found in Denmark.

A perusal of the foregoing literature demonstrates not only the great confusion regarding the identity of the causal species of the various diseases, but also the apparently wide distribution of the two earlier known fungi. In the course of time the names *Phoma pitya* and *P. abietina* have almost been regarded by some authorities as interchangeable and have been used in certain cases indiscriminately to indicate the fungi concerned. In order to clear up this confusion an examination of the type specimen of *P. pitya* has been made and authentic specimens of *P. abietina* and *Fusicoccum abietinum* have also been examined and compared with specimens of *Phomopsis Pseudotsugae*.

The identity of *Phoma pitya* Sacc.

The name *Phoma pitya* was first used by Saccardo in 1878 for the fungus collected by Magnus on dead branches of *Pinus sylvestris* in the Berlin Botanic Garden (Pl. XVIII, fig. 1). Some confusion has arisen owing to the fact that Thümen in his *Mycotheca universalis*, No. 1888, 1876, had used the same specific name *pitya* for a fungus on larch which he described as *Sphaeropsis pitya* Thüm.

Von Höhnel in 1909 instituted the new genus *Sclerophoma* and in it included *Sphaeropsis pitya* Thüm. This fungus which occurs on *Larix europaea*, had been removed by Saccardo ((51), vol. x) in 1892 to *Phoma*, and owing to the existence of *Phoma pitya* Sacc. it was necessary in so doing to change its specific name; it became therefore *P. pityella* Sacc. Diedicke (9), in 1911 gave a fuller description of the genus *Sclerophoma*, and cited *S. pitya* (Sacc.) v. Höhn. as a species placed in the genus by von Höhnel. This is evidently a misquotation since the species included by von Höhnel under the name *Sclerophoma pitya* (Thüm.) v. Höhn. was *Sphaeropsis pitya* Thüm. and not *Phoma pitya* Sacc. In 1912 Diedicke perpetuated this error in the Flora of the Mark Brandenburg by quoting "*Sclerophoma pitya* (Sacc.) v. Höhn." as synonymous with "*Phoma pitya* Sacc. Mich. I, S. 126; Syll. III, S. 173*; Allescher, VI, S. 196." Lind (31), did not appear to recognise *Sclerophoma* as a genus and placed *S. pitya* (Thüm.) v. Höhn. under *Phoma pityella* Sacc. He created a new combination *Phomopsis pitya* in which he included not only *Phoma pitya* Sacc. but also *P. abietina* Hart.

Grove in 1918 in discussing the genera *Phomopsis* and *Sclerophoma* gave a description of the latter but cited Diedicke as the authority for the genus. He described the species "*Sclerophoma pithya* Died., Pilz Brand. IX, 280 (? non v. Höhn. Fragm. Mykol., No. 402, 1909)," and gives amongst others, as synonyms "*Phoma pithya* Sacc." and "? *Phomopsis pithya* Lind., Dan. Fung. p. 421, 1913, = *Phoma abietina* Hartig (1888), = *Fusicoccum abietinum* Prill. et Delacr." Although Grove includes "? *Phomopsis pithya* Lind" in this list of synonyms, he later (17) explicitly states it cannot be *Sclerophoma pitya* Died.

It should be noted that Grove cites Diedicke as the authority for *Sclerophoma pitya* although Diedicke himself in the Pilz Brandenburg cites von Höhnel as the authority. However, since Diedicke was the first author to publish the combination *Sclerophoma pitya* (Sacc.), Grove was justified by the rules of nomenclature in attributing this combination to him.

* This is a misquotation for 73.

Van Luyk in 1923 discussed Diedicke's incorrect citation of von Höhnel and raised the question of the identity of Diedicke's fungus. He stated "Wenn der von Diedicke beschriebene Pilz eine gute *Sclerophoma*-Art und mit *Phoma pitya* Sacc. identisch ist, muss er also *Sclerophoma pitya* (Sacc.) Died. heissen." It appears that van Luyk was not prepared to make a definite statement as he had not seen the type specimen of *Phoma pitya*. He appeared to incline to the opinion that it was a species of *Phomopsis* for he stated "Da Saccardo diesen Pilz für die wahrscheinliche Nebenfruchtform von *Diaporthe pitya* Sacc. holt, ist es sehr wahrscheinlich, dass Lind mit Recht den Pilz als eine *Phomopsis* betrachtet." Petrak in 1923 in discussing the problem was evidently also of this opinion; he stated "*Phoma pitya* Sacc....schon Saccardo angegeben hat dass diese Art als Nebenfrucht zu einer *Diaporthe* gehoren soll. Ich glaube nun, dass diese Vermutung Saccardo's richtig und sein Pilz eine *Phomopsis* sein wird."

In order to solve definitely this problem the examination of the type specimen of *Phoma pitya* Sacc. was necessary—a necessity which had already been pointed out by van Luyk—"Eine Prüfung des Originalexemplars der *Phoma pitya* Sacc. wäre daher sehr wünschenswert." By the courtesy of Professor Gola, the Director of the Royal Botanic Garden at Padua we have been permitted to examine the type specimen of *P. pitya* Sacc.: upon a critical examination the species has been provisionally assigned to *Sclerophoma*; it therefore becomes *Sclerophoma pitya*. Although there is no evidence that Diedicke had ever seen this type specimen, yet judging from his description of the fungus which he had on *Pinus sylvestris* from Thuringia and our present knowledge, he was probably correct in his identification.

The question arises whether *Phoma pitya* Sacc. is identical with Thümen's *Sphaeropsis pitya*. We have not been able to examine the type specimen of the latter, but have seen a fungus collected by Rehm and distributed by Thümen in his Mycotheca universalis, No. 1888. This specimen, which was examined through the courtesy of the Keeper of Botany of the British Museum (Natural History) is a *Sclerophoma* but clearly differs from *P. pitya* in spore size and shape. The spores of *Sphaeropsis pitya* as given by Thümen are 4–7 × 2–2·5μ and are elliptical or ovate, while those of *P. pitya* are characteristically fusoid and according to Saccardo measure 9–11 × 2·5–3·5μ.

A consideration of the foregoing discussion shows that there are two species of *Sclerophoma* with the same specific name—*Scl. pitya* (Thüm.) v. Höhn. and *Scl. pitya* (Sacc.) Died. One of these must be changed and since the combination was first used for Thümen's fungus it must be retained for this species.

Consequently a new name is required for Saccardo's fungus. We therefore propose to name it *Sclerophoma Magnusiana* in honour of Professor Paul Magnus who discovered it in 1878.

Sclerophoma Magnusiana Wilson & Hahn.

Phoma pitya Sacc., Mich. I, 126, 1879, Sylloge, III, 73; *Scl. pitya* (Sacc.) Died., non *Scl. pitya* (Thüm.) v. Höhn.

Pycnidia distributed in close set rows or sparsely aggregated or scattered (Pl. XVIII, fig. 2), primordia distinct or arising close to adjacent primordia and fusing laterally, formed just below the epidermis in the uppermost layers of the bark parenchyma, soon becoming erumpent or subsuperficial as subspherical or cushion-shaped fruiting bodies which appear to sit almost superficially upon the bark surface (Pl. XVIII, fig. 3) when the outermost layers flake off; dull black, carbonaceous, with a granular surface; 125–460μ wide, 187·5–350μ high, at first completely closed, then breaking open irregularly without a definite ostiole. Pseudoparenchymatous cells of the outer pycnidial wall, sclerotioid, thick-walled, polygonal, fuliginous, gradually passing into the cells of the inner wall which are only faintly tinged or hyaline, and which face into a cavity without intervening conidiophores (Pl. XIX, fig. 4); cavity at maturity completely filled with spores. The spores arise directly from the cell walls, being produced by a budding process, wherein the contents of the inner peripheral cells lining the cavity are extruded to form spores (Pl. XIX, fig. 5); these are embedded in a colourless gelatinous matrix resulting from a histolysis of the primordial cells of the inner pycnidial structure. Spores unicellular, hyaline, characteristically spindle-shaped but varying to ovate; extremities acutely pointed, or gently rounded, becoming obtuse, symmetrical or asymmetrical; 6–12 × 2·5–4μ, commonly 8–10 × 3–3·5μ, many with a single large vacuole (Pl. XIX, fig. 6). The perfect stage is unknown. Saccardo associated *Diaporthe pitya* Sacc. with this fungus.

On dead twigs of *Pinus sylvestris* collected by P. Magnus in the Botanical Garden, Berlin, Germany, 1878 (specimen preserved in the herbarium of the Royal Botanic Garden, Padua, Italy). Also collected in Great Britain by J. W. Ellis on *Pinus sylvestris* at Higher Bebington, Cheshire, England, April 5th, 1912, and by Dr J. W. Munro, on young Scots pine, April, 1922 (specimens examined through the courtesy of the Director, Royal Botanic Gardens, Kew, England).

Grove (16) reports—"*Sclerophoma pithya* Died. (? non v. Höhn.) on small dead branches of *Pinus sylvestris*, King's Lynn (Plowright); Cheshire (Ellis). On the same, Edgbaston Botanic Gardens, Birmingham. March-April. Plowright's specimens

were sent to me so long ago as 1881, mixed with *Cenangium Abietis* Rehm, but remained unnoticed till this year (1918).... *Sclerophoma*, so far as at present known, appears to be only saprophytic." The specimen collected by Ellis in Cheshire to which Grove refers, is probably identical with that in the Kew Herbarium which we have identified as *Sclerophoma Magnusiana*. This fungus possesses spindle-shaped spores 8–12 × 3–4μ. The specimen was not recorded as parasitic. We have not seen the other specimens reported by Grove.

Phoma cembrae Karst. and *Sporonema strobilinum* var. *ramulorum* Vesterg. are given as synonyms for *Sclerophoma pityа* Died. by Grove. We have not seen the type specimens of these species and are unable to state whether they are identical with *Scl. Magnusiana*.

Rostrup (48, 49) identified a number of specimens from Denmark as *Phoma pityа*. These, which occur on a number of conifers, are preserved in the herbarium of the Botanical Museum, at Copenhagen. By the courtesy of the Director we have been enabled to examine certain of these and find that a number of species of *Sclerophoma* are amongst them, but we have been unable to identify any of these as *S. Magnusiana*. Lind (31) in his description of Rostrup's herbarium has placed all these specimens under *Phomopsis pityа* (Sacc.) Lind. The identity of Lind's *P. pityа* (Sacc.) is discussed in a later paper (18).

Since the institution of the genus *Sclerophoma* by von Höhnel a number of papers have appeared dealing with the origin of the spores in this genus. In his original description, von Höhnel (27) stated "Sporen...durch schleimige Histolyse des Kerngewebes entstehend." In a later paper (28) he further described the production of spores by cleavage within a primordial cell, "Conidien im innern der hyalinen Zellen einzeln oder zu mehreren gebildet,...." This endogenous spore origin has been further investigated in *Sclerophoma pityophila* (Cda.) v. Höhn. by van Luyk in 1923 who is not in agreement with the method of origin as described by von Höhnel. Van Luyk repeatedly demonstrated that the spores of this species are formed by budding from the walls of the cells. Petrak in 1923 discussed this problem, and in 1924 he again described the "Sclerophomaceen" and, while admitting that certain genera of von Höhnel's "Endogenosporae" produce spores by budding directly from the walls of the cells of the hymenium, yet he still maintains that certain groups reproduce endogenously in the manner stated by von Höhnel. Included in one of the endogenous spore groups which Petrak retains is *Sclerophoma pityophila*, which van Luyk asserts, as stated above, produces spores by the processs of budding. Archer (5) discussed the "endogenous

spore origin" controversy, and submitted further proof with regard to the production of spores by budding for *Phoma Astragali* Cooke & Hark. and *Diplodina coloradensis* Ell. & Everh. He could find no trace of endogenous spore origin. These findings also hold true for *Sarcophoma Mirbelii* (Fr.) v. Höhn., *Sclerophoma concaviuscula* (Ell. & Barth.) v. Höhn. and *Dothichiza minor* (Ell. & Everh.) v. Höhn.

Spore formation has been examined in *Sclerophoma Magnusiana* and we find that here the spores are budded off from the walls of the hymenial cells lining the cavity as described by van Luyk for *S. pityophila* and Archer for other fungi of von Höhnel's Endogenosporae (Pl. XIX, figs. 4, 5). We were unable to determine any endogenous formation of spores, although this might possibly take place under certain physiological conditions of growth.

The identity of *Phoma abietina* Hart.

In his original description of the fir bark disease (Pl. XX, figs. 7, 8) Hartig (19, 20) regarded the organism to which the "Einschnürungskrankheit" of the smaller branches of silver fir is attributed, as a new species which he designated by the preliminary name *Phoma abietina*. He did not state the size of the spores or sporophores, but he does describe the shape of the former and the nature of the fruit-body in which these are borne. Prillieux and Delacroix (43) dealing with apparently the same fungus in France preferred to designate the fungus as *Fusicoccum abietinum* Prill. & Delacr. and gave a complete description of the fungus. They identified their organism with a specimen sent them by Hartig from Germany. Originally Prillieux and Delacroix had regarded their fungus as *Dothiorella pitya* Sacc. (42) but a little later upon comparison with the type specimen of Saccardo's fungus (*Fungi Veneti Ser.* IV, 5; *Sylloge fungorum*, III, 241) decided that they were dealing with quite another fungus. We have not seen the type of *Dothiorella pitya* Sacc. which is reported to occur on *Abies* and *Pinus Strobus* in northern Italy but the figure given in Saccardo's Fungi italici, tab. 1454 shows an organism with spores apparently quite distinct in shape and size and with different pycnidial stromata from those belonging to *Phoma abietina*. Mer (35) stated that the French organism offers "assez de ressemblance avec celles décrites et figurées par Saccardo." A further study of the Italian organism may reveal a closer relationship with the northern species. The history of *Phoma abietina* and *P. pitya* shows that the former fungus has been referred to by some investigators by the title given originally to it by Hartig, whilst others prefer that given by the two French investigators.

We have not seen the type specimen of *Phoma abietina* Hart. Apparently Hartig did not deposit an "Originalexemplar" at Munich. Nor have we seen the specimen from which Prillieux and Delacroix originally described their fungus as *Fusicoccum abietinum* (*Phoma abietina* Hart.). We have, however, examined the following material*:

(*a*) *Phoma abietina* Hart. on *Abies pectinata* collected by Professor Hartig in the Bavarian Forest. Specimen from the Forstbotanisches und Pflanzenpathologisches Institut, München.

(*b*) *Phoma abietina* Hart. on *Abies pectinata* from Dr Robert Hartig's pathological collection purchased by the Royal Botanic Garden, Edinburgh, Scotland from Dr K. von Tubeuf. This specimen is probably at least a co-type of Hartig's original collection.

(*c*) *Fusicoccum abietinum* Prill. & Delacr.—fresh field material from the silver fir forests of the Jura Mountains (Pl. XX, figs. 7, 8).

(*d*) *Phoma abietina* Hart. on *Abies pectinata* from the Herbarium of P. Magnus, Institut für allgemeine Botanik, Hamburg.

Upon examination of the German herbarium material, these specimens are found to resemble very closely the fungus described in detail by Prillieux and Delacroix as *Fusicoccum abietinum* and that briefly described and figured by Hartig in 1889 as *Phoma abietina*. There is no doubt that we have had under investigation the same fungus as that observed by both the German and French investigators. For the most part the fruit-bodies are found to be distinctly multilocular (Pl. XX, fig. 9) although occasionally smaller pycnidia are observed with only a single chamber (Pl. XX, fig. 10), or the cavity may be divided by incomplete partitions. The wall is thin below but thickens towards the apex, the thickened portion consisting of fuliginous pseudoparenchymatous cells.

The fruit-body of *Phomopsis abietina* is not superficial (Pl. XX, figs. 9, 10) as in the genus *Fusicoccum*, i.e. *Fusicoccum castaneum* Sacc. (8), or *F. putrifaciens* Shear (54), wherein the irregularly chambered fruit-body upon maturity becomes erumpent or subsuperficial. While both the fruit-bodies of

* We are deeply indebted to the following for the privilege of examining the specimens of *Phoma abietina* Hart. (*Fusicoccum abietinum* Prill. & Delacr.):
(*a*) Prof. F. von Tubeuf, Forstbotanisches Institut, Munich.
(*b*) The Regius Keeper of the Royal Botanic Garden, Edinburgh, Scotland.
(*c*) Professor O. Guimer, National College of Forestry, Nancy, France.
(*d*) The Director of the Botanical Institute, Hamburg.

Fusicoccum and *Phomopsis* are ectostromatic in origin, in the genus *Phomopsis* the tendency is to regard the fruit-body as being only partially erumpent and remaining more or less incorporated with the upper layers of the cortical tissue in which it is embedded. Upon maturity the cone or cushion-shaped pycnidial stromata rupture the epidermis disclosing the protruding apices of the fruit-bodies. Upon these apices exudations of spores appear either as minute whitish mucilaginous droplets or as coiled tendrils. With maturity these fruiting bodies tend to empty themselves and fall away along with bits of the broken epidermis so that the surface of the canker appears minutely pocketed with the discoloured bark tissue and basal remains of the pycnidial stromata.

The multilocular condition of the fruit-body we consider to be the result of the fusing of primordia to form a compound structure. These confluent primordia give rise to the composite, many chambered pycnidium, discussed by Archer (5) and figured by Prillieux in his text-book (41), reproduced here in Pl. XX, fig. 9, and also by Hartig (20), and Böhm (6). The pycnidia tend to be immersed in or incorporated with the cells of the outer cortex and only the upper part becomes exposed by the rupture of the superficial tissues. The spores, which are borne on persistent sporophores, are much larger as compared with the spores of *Phomopsis Pseudotsugae* and *Sclerophoma Magnusiana*, their range being 9·5–15 × 4–6μ, commonly 12–14 × 4–5μ; characteristically spindle-shaped with acute extremities, asymmetrical, or symmetrical as figured by Prillieux, by Hartig and by Böhm; one, two or even three large guttules may be present. "B" spores have not been observed either in the herbarium material or in the fresh canker material received from the Jura Mountains. The latter afforded abundant typically fusoid spores, agreeing in size and shape with the herbarium specimens mentioned above. Germination was readily secured in ordinary tap water, the spores producing vigorous germ tubes originating apically or laterally. The culture characteristics of this fungus, which show striking differences from those of *P. Pseudotsugae*, will be reported in a later paper.

For the reasons discussed above we propose to place the fungus in the genus *Phomopsis*; the name therefore becomes:

Phomopsis abietina (Hart.) Wilson & Hahn.

Phoma abietina Hart. *Lehrbuch der Baumkrankheiten*, ed. II, 124, 1889; *Dothiorella pitya* Prill. & Delacr. (nec Sacc.), in *Bull. Soc. Mycol. France*, VI (1890), 98; *Fusicoccum abietinum*, Prill. & Delacr. *tom. cit.* p. 176; nec *Phomopsis abietina* Grove, in *Journ. Bot.* LIX (1921), 16.

Stromata thickly scattered subconical or subglobular, with a flattened base, seated upon and incorporated with the inner layers of the periderm, with only the apex protruding; black, unilocular, 120–300 × 60–180μ, or multilocular, tending to become unilocular with slender partial septa, 360–500 × 240–380μ; wall very thin below becoming much thicker above, fuliginous, becoming paler towards the hymenium, dehiscing at one ostiole; spores hyaline, symmetrical or asymmetrical, unicellular, spindle-shaped with acute ends, 9·5–15 × 4–6μ commonly 12–14 × 4–5μ with 1–3 guttules, extruding in a whitish tendril or drop; sporophores persistent, subulate, 10–15 × 1·5–2μ; B-spores not observed.

Authentic specimens of *Phomopsis abietina* have been identified by the writers only from Germany and France, and only upon *Abies pectinata*; typical specimens have not been collected in Great Britain.

We have not seen specimens of this fungus on the Douglas fir. Organisms closely resembling *P. abietina* have been collected on the silver fir and other conifers in the British Isles and these will be reported upon in a subsequent paper. On account of the large importation of conifers from the continent into Great Britain it is not unlikely that typical *P. abietina* is already here on the silver fir. The specimen of *Fusicoccum abietinum* reported as occurring on *Abies Veitchii* in the United States (4, 56), 1922, has been received through the courtesy of Dr H. C. Young, Ohio Agricultural Experiment Station, Wooster, Ohio, and Dr Haven Metcalf of the Office of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture. A critical examination of this fungus indicates that it is not *P. abietina* and its identity will be discussed in a later paper. We have not seen specimens of *Phoma abietina* reported by Doidge (11) from South Africa.

The combination *Phomopsis abietina* Grove was apparently not based on the fungus described by Hartig, and Prillieux and Delacroix; for Grove's description is derived from specimens of *Phomopsis* on *Pseudotsuga Douglasii* from Perthshire (17). His description differs considerably from that of the German and French authors of the continental fungus on *Abies pectinata*. *Phomopsis abietina* as used by the authors has quite a distinct significance and refers only to the fungus described by Hartig, and Prillieux and Delacroix.

The perfect stage of *Phoma abietina* has not as yet been determined. Hartig (20) attempted to connect the fungus with *Peziza calycina* by infection experiments but failed. Rehm (45) gives *Dasyscypha calyciformis* Willd. as the perfect stage, but Schellenberg (52) maintained that the fungus belonged to another

Discomycete. Prillieux (41) did not mention the ascigerous stage for *Fusicoccum abietinum* in his text-book and in 1907 Henry (24), reported the perfect stage as still unknown. Some species of *Diaporthe* may prove to be the perfect stage of this fungus.

Relationship between *Phomopsis Pseudotsugae* Wilson and the Foregoing Fungi.

The above consideration of the identity of *Phoma pitya* Sacc. and *P. abietina* Hart. demonstrates that these fungi may now be considered as quite distinct morphologically from *Phomopsis Pseudotsugae*. This fungus was first described in 1920 (59, 60), and more fully in 1925 (64) as a parasite of *Pseudotsuga Douglasii*. It was also found to attack *Larix leptolepis* (61, 63), *L. europaea* (64), *Pseudotsuga glauca* (64), and *Abies grandis* (64). An account of the disease on *P. Douglasii* was given by Alcock in 1921. Recently the fungus has been found attacking the branches of *Cedrus atlantica* both in England and Scotland. On the Douglas fir it causes a die-back of young shoots (Pl. XXI, fig. 11) and produces well-marked cankers on the older stems (Pl. XXI, figs. 12, 13, 14).

The synonymy and relationships of *Phomopsis Pseudotsugae* have already been discussed (7, 64) and it was suggested by Wilson that the species had been previously included with other forms by Lind under *P. pitya*, and by Grove under *P. abietina*. During the examination of Rostrup's herbarium a specimen of *P. Pseudotsugae* on *Abies pectinata* collected in Denmark in 1892 was found. Very probably the specimens on *Pseudotsuga Douglasii* described by Grove (17) as *Phomopsis abietina* are *P. Pseudotsugae*, for the description of the spores agrees rather closely both in shape and size with the spores of the latter fungus. Grove states that "they also agree with what Hartig says and figures," but this does not appear to be so, for the spores figured by Hartig, as has already been pointed out, are distinctly fusoid and the spore size is much greater in all respects. As in the silver fir bark fungus, "B" spores (64) have not been observed although *P. Pseudotsugae* has been grown for several years in artificial culture on various kinds of media, and the fruit-bodies obtained culturally, as well as those produced in nature have been under constant observation.

As some modifications have been found necessary in the account of the fungus an emended description is now given:

Phomopsis Pseudotsugae Wilson.

Pycnidia densely distributed obpyriform or lenticular with a flattened base seated upon and incorporated with the inner

layers of the periderm with only the apex protruding, black, 0·3–1 mm. in diameter, unilocular (Pl. XXI, fig. 15) or multilocular (Pl. XXI, fig. 16) tending to become unilocular with slender partial septa, texture everywhere several cells thick more or less hyaline and tinged green below, thicker and black above, opening at a definite ostiole; spores hyaline unicellular elliptic-fusoid, extremities obtuse or subacute, 4·5–8·5 × 2–4μ, occasionally with small oil drops, sporophores subulate, 12–14 × 1–2μ; "B" spores not observed.

Hab. on branches and leaves of *Pseudotsuga Douglasii*, *P. glauca*, *Larix europaea*, *L. leptolepis*, *Abies grandis*, *A. pectinata* and *Cedrus atlantica* in Great Britain; also on *Pseudotsuga Douglasii* in Ireland.

Phomopsis Pseudotsugae has been found on *Pseudotsuga Douglasii* in Denmark by Boyce in 1925, in the island of Bornholm, and was collected by the senior author on the same host near Copenhagen the following year. Material of the fungus was also kindly forwarded by Dr C. A. Jorgensen from the mainland of Denmark in 1926. Specimens of the Douglas fir seriously injured by this species were also collected by Wilson, at Loo, Schovenhorst and Baarn in Holland in 1926. The trees showed typical cankers and dying back of the young shoots; both nursery stock and trees up to fifteen years old were attacked. During a recent visit to Scandinavia, Hahn (1927) observed *P. Pseudotsugae*, in the coastal region at Softeland, Norway*, seriously attacking blue Douglas fir (*Pseudotsuga glauca* Mayr.), killing the terminal shoots and branches. The death of many trees had been caused by this parasite. Through the courtesy of Professor Lagerberg a herbarium specimen of a diseased shoot of *Pseudotsuga Douglasii* preserved among the pathological collection at the Skogshogskolan, Stockholm, Sweden, collected at Vastergotland, South Sweden in 1917 and attributed to *Phoma pitya*, was examined and identified as typical *Phomopsis Pseudotsugae*. Diseased Douglas fir shoots from Glusted, Jutland, also examined through the courtesy of Magister Rostrup, Plantapatologisk Laboratorium, Copenhagen, were found to be infected with the same fungus. These recent findings extend the previously known distribution of the *Phomopsis* disease of Douglas fir beyond the confines of Great Britain to the continent, including Holland, Denmark, Norway and Sweden. For practical purposes it must also be considered as present in Germany, Belgium and France.

* Acknowledgment is made to Professor Hagem, Botanisk Museum, Bergen, and Mr Ivar Jorstad, Botanisk Museum, Oslo, for every possible assistance in studying the *Phomopsis* disease of Douglas fir in Norway.

SUMMARY.

During the last half-century considerable confusion has existed in the forestry and mycological literature concerning the identity of *Phoma pitya* Sacc. and *P. abietina* Hart., fungi reported as parasitic on the Douglas fir and other conifers. Recently a parasitic fungus *Phomopsis Pseudotsugae* on the Douglas fir (*Pseudotsuga Douglasii*) has been described occurring in Great Britain and on the European continent, which showed certain close relationships, both morphological and physiological, with the two well-known fungi referred to above. A critical study for the purpose of differentiating the three fungi was considered highly desirable for purely scientific as well as practical purposes.

Phoma pitya Sacc. was found upon the examination of the type specimen to be a *Sclerophoma*. According to the rules of nomenclature the name must be changed as there is already a *Sclerophoma pitya* (Thüm.) v. Höhn. and the fungus has been fully described as *Sclerophoma Magnusiana* Wilson and Hahn.

Phoma abietina Hart. is now considered to belong to the genus *Phomopsis* and is called *Phomopsis abietina* (Hart.) Wilson and Hahn. The name *P. abietina* should be applied only to fungi identical with *Phoma abietina* Hart. and *Fusicoccum abietinum* Prill. and Delacr.

Phomopsis Pseudotsugae Wilson is distinct morphologically and physiologically from *P. abietina*. Culture studies have indicated sharp differences. *P. Pseudotsugae* is a true parasite of the Douglas fir and other conifers, killing the young shoots and terminals and forming a canker on the larger branches and trunks. To *P. abietina* is attributed the cause of a canker-constriction of the smaller branches of *Abies*. The latter fungus has not been observed to occur on the Douglas fir, nor in Great Britain. *Sclerophoma Magnusiana* is very probably only a saprophyte.

An extensive bibliography is given which indicates the considerable amount of observational data and investigation which has accumulated during the past fifty years concerning the foregoing coniferous fungi.

REFERENCES.

(1) ALCOCK, N. L. A *Phomopsis* disease of Douglas fir. Gard. Chron. LXIX (1921), 45.

(2) ALLESCHER, A. Fungi imperfecti: in Rabenhorst's Kryptogamen-Flora. VI. 1901.

(3) ANON. Absterben der Triebspitzen bei der Douglastanne. In Fragenkasten. Mitt. d. deutsch. Dendrol. Ges. XXXI (1921), 329.

(4) —— *Fusicoccum abietinum* (Hart.) Prill. and Del. on *Abies Veitchii*. Plant Disease Survey, United States Dept. Agric., Bureau of Plant Industry, Supp. XXIX (1923), 395.

(5) Archer, W. A. Morphological characters of some Sphaeropsidales in culture. Ann. Mycol. xxiv (1926), 1–84.
(6) Böhm, B. Über das Absterben von *Thuja Menziesii*, Dougl. und *Pseudotsuga Douglasii* Carr. Zeitschr. f. Forst- u. Jagdwesen, xxviii (1896), 154–161.
(7) Boyce, J. S. Observations on forest pathology in Great Britain and Denmark. Phytopathology, xvii (1927), 1–18.
(8) Diedicke, H. Die Gattung *Phomopsis*. Ann. Mycol. ix (1911), 8–35.
(9) —— *Dothiopsis*, *Sclerophoma* and *Sclerotiopsis*. Ann. Mycol. ix (1911), 279–285.
(10) —— Kryptogamen-Flora der Mark Brandenburg, ix (1912), 280.
(11) Doidge, E. M. A preliminary check list of plant diseases occurring in South Africa. Bot. Survey, S. Africa, Memoir vi, 1924.
(12) Fabricius, O. Douglas- og Sitkagran. Saertryk af Dansk Skovforenings Tidsskr. (1926), 484–7.
(13) Farquharson, C. O. Tree diseases due to fungi. Additional Scottish Records in 1910–11. Ann. Scot. Nat. Hist. (1911), 240–1.
(14) Forbes, A. C. Some diseases of conifers. Gard. Chron. ser. 3, xix (1896), 553–4.
(15) Grove, W. B. British Species of *Phomopsis*. Kew Bull. (1917), 49–52.
(16) —— *Sclerophoma pithya* Died. New or noteworthy fungi, Pt vi. Journ. Bot. lvi (1918), 292–4.
(17) —— *Phomopsis abietina* Grove. Mycological notes, Pt v. Journ. Bot. lix (1921), 16–17.
(18) Hahn, G. G. *Phomopsis conorum* (Sacc.) Died.—an old fungus of the Douglas fir and other conifers. Trans. Brit. Mycol. Soc. xiii (1928), 278.
(19) Hartig, R. Eine Krankheit der Weisstanne. Sitzungsbericht des Botanischen Vereins in München. Bot. Centralbl. xxxvii (1889), 78–79.
(20) —— *Phoma abietina* n. sp. Der Tannenrindenpilz. Lehrbuch der Baumkrankheiten, ii Aufl. (1889), 124–6.
(21) —— *Phoma abietina* n. sp. The fungus of the cortex of the silver fir. Diseases of Trees. English Trans. by W. Somerville and Marshall Ward. (1894), 138–9.
(22) Hausrath, D. H. Das Verhalten der in badischen Waldungen angebauten ausländischen Holzarten im Vegetationsjahr 1921–22. Mitt. d. deutsch. Dendrol. Ges. xxxiii (1923), 162–3.
(23) Henry, E. La maladie du sapin dans les forêts du Jura. Compt. Rend. Acad. Sci. cxlv (1907), 725–7.
(24) —— Le champignon de l'écorce du sapin *Phoma abietina* R. Hartig (*Fusicoccum abietinum* Pr. et Del.) dans le haut Jura. Bull. Soc. Sci. Nancy, ser. 3, viii (1907), 361–378.
(25) —— La maladie du rouge dans les sapinières du Jura. Ann. Forest., Rev. Eaux et Forêts, xlvi (1907), 673–682, 705–710.
(26) Hickel, R. Parasites; le sapin de Douglas. Bull. Soc. Dendrol. France, xliv (1922), 74–75.
(27) Höhnel, F. von. Über einige *Phoma*-Arten auf Nadelhölzern. Fragmente zur Mykologie. Sitz. Kais. Akad. d. Wiss. Wien, Math.-nat. Kl. cxviii, Abt. i (1909), 1230–4.
(28) —— System der Fungi imperfecti Fuckel. Falck's Mykol. Unters. und Berichte, i, Heft 3 (1923), 301–369.
(29) Koning, M. de. Boschbescherming de leer der ziekten en beschadigingen der houtgewassen, p. 160. Zutphen, 1922.
(30) Leven, G. *Phoma pithya*. A fungus on the Douglas fir. Trans. Roy. Scot. Arb. Soc. xv (1896–8), 319–320.
(31) Lind, J. Danish Fungi. 1913.
(32) Lindau, G. In Sorauer's Handbuch der Pflanzenkrankheiten. ii (1908), 399.
(33) Luyk, A. van. Über einige Sphaeropsideae und Melanconieae auf Nadelhölzern. Ann. Mycol. xxi (1923), 133–142.
(34) Maublanc, A. Sur la maladie des sapins produite par le *Fusicoccum abietinum*. Bull. Soc. Mycol. France, xxiii (1907), 160–173.

(35) Mer, E. Description d'une maladie nouvelle des rameaux de sapin. Bull. Soc. Bot. France, xxxvii (1890), 38–49. (Summary by R. Ferry, Rev. Mycol. xvii (1895), 25–29.)
(36) —— Recherches sur la maladie des branches de sapin, causée par le *Phoma abietina* R. Hartig (*Fusicoccum abietinum* Prill. et Del.). Journ. de Bot. vii (1893), 364–375.
(37) —— Le *Phoma abietina*, maladie parasitaire des branches de sapin (nouvelles recherches). Ann. Forest., Revue des Eaux et Forêts, xlvii (1908), 609–621.
(38) Neger, F. W. Die Krankheiten unserer Waldbäume, pp 173-174. 1924.
(39) Petrak, F. Über einige *Sclerophoma*-Arten auf Koniferen. Mykologische Notizen. Ann. Mycol. xxi (1923), 264–8.
(40) —— Übersicht und Kritik der bisher bekannten Sclerophomaceen-Gattungen. Mykologische Notizen. Ann. Mycol. xxii (1924), 1–182.
(41) Prillieux, E. Maladies des Plantes Agricoles, ii, Paris (1897), 285–9.
(42) Prillieux, E. and Delacroix, G. Note sur le *Dothiorella pitya* Sacc. Bull. Soc. Mycol. France, vi (1890), 98.
(43) —— —— Sur deux parasites du sapin pectiné: *Fusicoccum abietinum* Prill. et Del., et *Cytospora Pinastri* Fr. Bull. Soc. Mycol. France, vi (1890), 174–8.
(44) Prillieux, E. and Maublanc, A. La maladie du sapin pectiné dans le Jura. Compt. Rend. Acad. Sci. cxlv (1907), 699–701.
(45) Rehm, H. Ascomyceten: Die Pilze Deutschlands, Oesterreichs und der Schweiz. In Rabenhorst's Kryptogamen-Flora, iii (1896), 835.
(46) Rostrup, E. Beretninger om Undersøgelser, foretagne i 1884 og 1885 ifølge Finansministeriets Foranstaltning, angaaende Snyltesvampeangreb paa Naaletraeer, saerligtde forskellige Fyrrearter, paa alle Statsskov-distrikterne i Jylland. 1885.
(47) —— Undersøgelser over Snyltesvampes Angreb paa Skovtraeer i 1883–1888. Tidsskr. f. Skovbrug, xii (1890), 175–238. (Summary in Bot. Centralbl. xliii (1890), 353–6.)
(48) —— Plantepatologi, pp. 567–9. 1902.
(49) —— Bornholms Svampe. Bot. Tidsskr. xxvii (1906), 378.
(50) Saccardo, P. A. Michelia, i. 1878.
(51) —— Sylloge fungorum. 1882–1926.
(52) Schellenberg, H. C. Das Absterben der sibirischen Tanne auf dem Adlisberg. Mitt. a. d. Schweiz. Zentralanst. f. d. forstl. Versuchsw. viii (1905), 274.
(53) Schwappach, A. Neuere Erfahrungen über das Verhalten von *Pseudotsuga Douglasii* und *Picea sitkaënsis*. Mitt. Deutsch. Dendrol. Ges. xviii (1909), 95–99. (Rev. in Centralbl. für Bakt. Para. und Infekt. xxix (1911), 89–90.)
(54) Shear, C. L. Endrot of Cranberries. Journ. Agr. Res. xi (1917), 35–41.
(55) Somerville, E. Report of the Honorary Consulting Cryptogamist. Trans. Roy. Scot. Arb. Soc. xv (1896–98), 190–2.
(56) Stevenson, J. A. Foreign Plant Diseases. A manual of economic plant diseases which are new or not widely distributed in the United States. United States Dept. Agric. (1926), 3.
(57) Tubeuf, K. von. Einschnürungskrankheit der Tannenzweige. Pflanzenkrankheiten durch kryptogame Parasiten verursacht, pp. 482–3. 1895.
(58) —— Diseases of Plants induced by Cryptogamic Parasites, pp. 465–7. Eng. ed. by W. G. Smith. 1897.
(59) Wilson, M. A new disease of the Douglas fir in Scotland. Trans. Roy. Scot. Arb. Soc. xxxiv (1920), 145–9.
(60) —— A new species of *Phomopsis* parasitic on the Douglas fir. Trans. and Proc. Bot. Soc. Edinburgh, xxviii (1920), 47–49.
(61) —— A newly-recorded disease of the Japanese larch, caused by *Phomopsis Pseudotsugae*. Trans. Roy. Scot. Arb. Soc. xxxv (1921), 73–74.
(62) —— The diseases of the Douglas fir. Trans. Roy. Scot. Arb. Soc. xxxv (1921), 77–78.
(63) —— The occurrence of the *Phomopsis* disease of the Japanese larch in Yorkshire. Trans. Roy. Scot. Arb. Soc. xxxvi (1922), 115–6.
(64) —— The *Phomopsis* disease of conifers. Bull. 6, Forestry Commission. 1925.

EXPLANATION OF PLATES XVIII—XXI.

All the figures in Plates XVIII and XIX are of *Sclerophoma Magnusiana* comb. nov. and are made from type specimen material of *Phoma pitya* Sacc. on *Pinus sylvestris*.

PLATE XVIII.

Fig. 1. Photograph of type specimen and label.
Fig. 2. Drawing of fruit bodies. ×4.
Fig. 3. Pycnidium in section showing its superficial position. ×200.

PLATE XIX.

Fig. 4. Part of pycnidium in section showing wall, hymenial layer and spores. ×500.
Fig. 5. Part of pycnidium showing thickened wall cells, hymenial layer and spore origin by budding. ×2000.
Fig. 6. Spores. ×2000.

PLATE XX.

All the figures are of *Phomopsis abietina* comb. nov. on *Abies pectinata* from Jura, France.

Fig. 7. Branch showing "Einschnürungskrankheit." Natural size.
Fig. 8. A similar branch showing the swelling above the constriction. ×2.
Fig. 9. A reproduction of the figure of a multilocular pycnidium of *Fusicoccum abietinum* given by Prillieux.
Fig. 10. A unilocular pycnidium. ×170.

PLATE XXI.

All the figures are of *Phomopsis Pseudotsugae* Wilson on *Pseudotsuga Douglasii*.

Fig. 11. Four-year old tree with leading shoot killed.
Fig. 12. Four-year old tree attacked near ground level. The stem is considerably swollen about the well-marked constriction.
Fig. 13. Part of main stem near the base of a tree eight years old. The base of an infected lateral branch is seen in the middle of the canker.
Fig. 14. Part of the main stem of a tree sixteen years old showing a canker in side view. An infected lateral branch is seen on the right; the callus tissue is very evident. The dead bark bearing the small black pycnidia is about to be cast off.
Fig. 15. Unilocular pycnidia; one on the left and two on the right.
Fig. 16. A compound pycnidium.

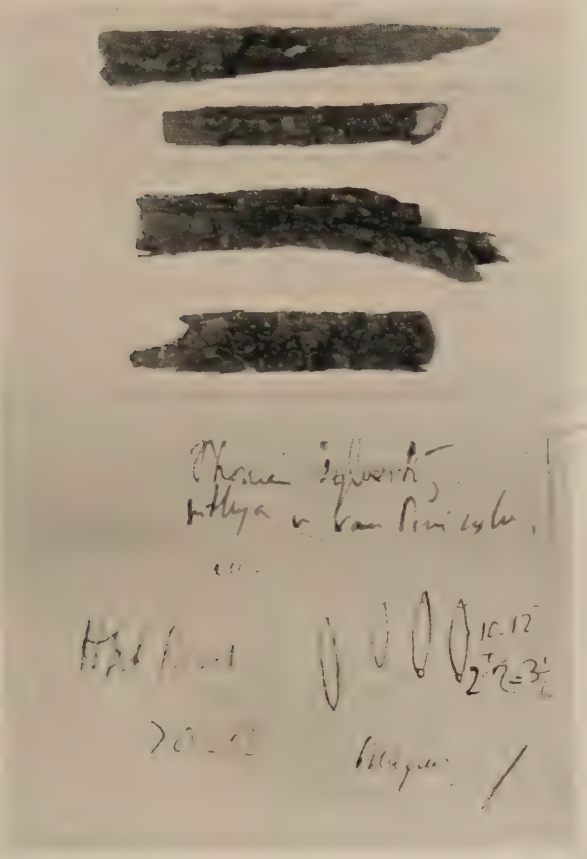
PHOMOPSIS CONORUM (SACC.) DIED.—AN OLD FUNGUS OF THE DOUGLAS FIR AND OTHER CONIFERS.

By Glenn Gardner Hahn, B.Sc., M.Sc.
(*From the Mycological Department, University of Edinburgh.*)

(With Plates XXII, XXIII)

Introduction.

During the investigation of certain of the fungi occurring on the Douglas fir (*Pseudotsuga Douglasii* Carr.) closely related to *Phomopsis Pseudotsugae* Wilson, *Phomopsis conorum* (Sacc.) Died. was observed in Great Britain on this host, which apparently has not been heretofore recorded. On account of its frequent occur-



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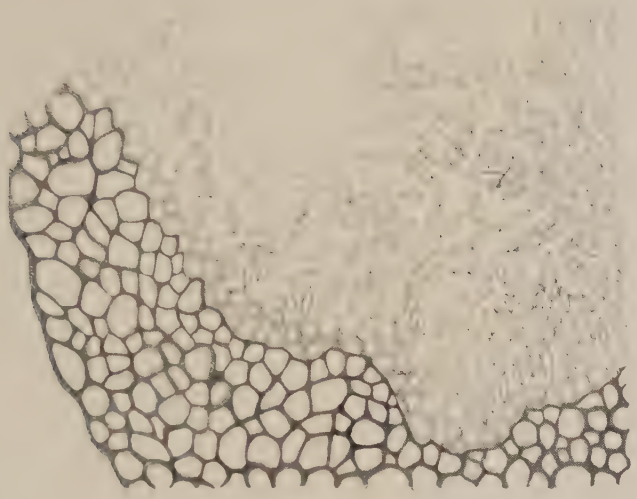
SCLEROPHOMA MAGNUSIANA WILS. & HAHN



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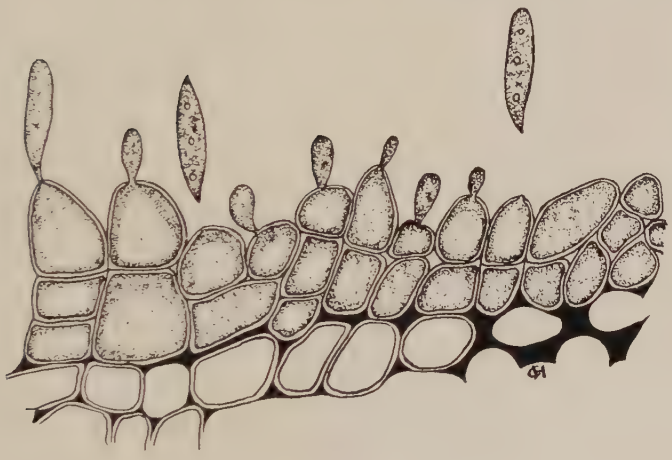

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SCLEROPHOMA MAGNUSIANA WILS. & HAHN

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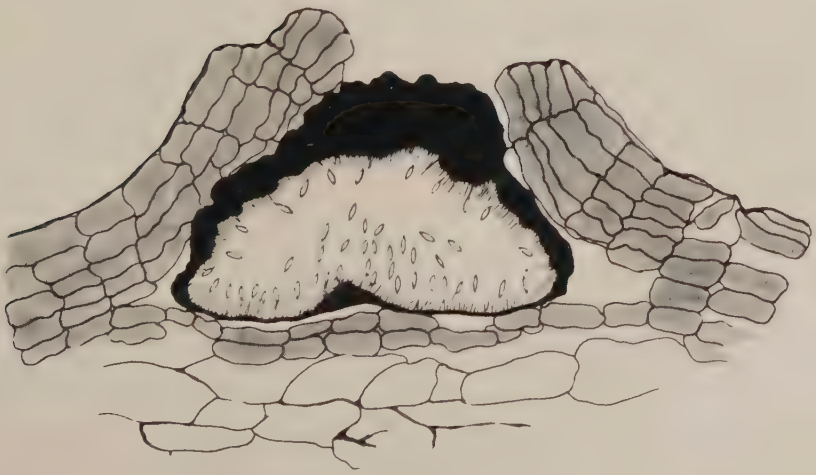

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PHOMOPSIS ABIETINA (HART.) WILS. & HAHN

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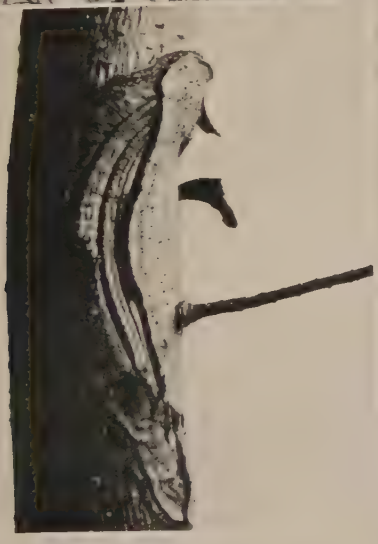

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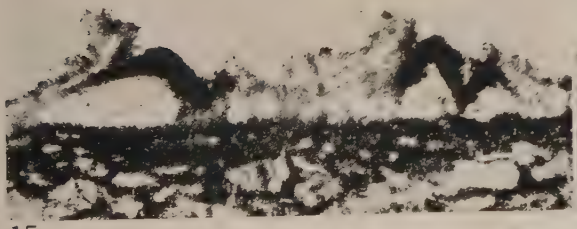

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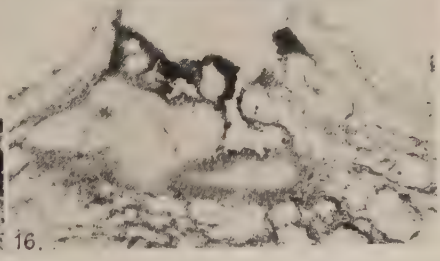

16.

PHOMOPSIS PSEUDOTSUGAE WILS.

rence in different parts of Scotland, and in Wales, on the dead and dying shoots of the Douglas fir, particularly upon young nursery plants, an investigation of the fungus was considered desirable, first regarding its relation to *P. Pseudotsugae*, which causes the *Phomopsis* disease of Douglas fir, and second, its possible parasitism.

This species of *Phomopsis* has also been found on the continent on shoots of the green Douglas fir, both among herbarium specimens and on freshly collected diseased material. The fungus was observed in European herbarium material as the result of the investigation of the identity of *Phoma pitya* Sacc. (see p. 268).

During the study of *Phoma pitya*, specimens identified by E. Rostrup as this fungus on Douglas fir and other conifers, and placed by him in his Svampesamling, were examined. None of these specimens so identified proved, in the light of our present knowledge, to be *Sclerophoma Magnusiana*. A number of different fungi were found, amongst them a *Phomopsis* sp. which morphologically is identical with the newly observed *Phomopsis conorum* from Great Britain. The identity of this Danish *Phomopsis* species and that of the other fungi included by Rostrup under *Phoma pitya* are now discussed in connection with the emended description of *Phomopsis conorum* originally regarded as a species occurring only on cones.

Rostrup's *Phoma pitya*.

Rostrup regarded Saccardo's *Phoma pitya* as a parasite occurring on a considerable number of conifers. In 1885, he stated that this fungus was responsible for a disease in a large plantation of *Picea excelsa* Lk. planted in 1882. A further account of this disease was given in 1890, and Douglas fir (*Pseudotsuga Douglasii*) mentioned as an additional host attacked. Rostrup regarded *Phoma pitya* as identical with *P. abietina* Hart. to which the "Einschnürungskrankheit" of the silver fir has been attributed. In 1902 in his Plantepatologi, Rostrup described and figured this disease of Douglas fir reproduced here in Pl. XXII, fig. 2 *a*, which he attributed to *P. pitya* and he also listed other hosts. These included *Abies pectinata*, *A. balsamea*, *Picea excelsa*, *Pinus sylvestris*, *P. Strobus*, *P. montana* and *Larix europaea*. He cited the death of the terminals and side shoots of two- and three-year old seedlings of *Abies pectinata*, apparently due to the same cause. In 1906 he recorded the fungus on Douglas fir and *Pinus Strobus* from Bornholm.

Lind in 1913 in his account of Rostrup's herbarium made the new combination *Phomopsis pitya* for which he gave as synonyms

—*Phoma pitya* Sacc., *P. abietina* Hart. and *Fusicoccum abietinum* Prill. & Delacr. Lind likewise regarded his fungus as a true parasite, recording it on *Abies balsamea, A. pectinata, A. concolor, Picea excelsa, Pinus sylvestris, P. montana, P. Strobus, Pseudotsuga Douglasii,* and on a new host, *Juniperus virginiana.*

Through the kindness of the Director of the Botanical Museum at Copenhagen and of Dr Wilson who arranged for the loan of Rostrup's herbarium specimens of *Phoma pitya,* I have been permitted to examine the following packets:

No. 3	*Phoma pitya* Sacc.		(= *P. abietina* Hart.)			on *Pseudotsuga Douglasii.*
No. 4	,,	,,	(=	,,	,,)	on *Pseudotsuga Douglasii.*
No. 5	,,	,,		—	—	on *Pseudotsuga Douglasii.*
No. 6	,,	,,		—	—	on *Juniperus virginiana.*
No. 7	,,	,,		—	—	on *Abies pectinata.*
No. 8	,,	,,		—	—	on *A. concolor.*
No. 9	,,	,,		—	—	on *A. balsamea, A. pectinata.*
No. 10	,,	,,		—	—	on *Pinus sylvestris, P. montana, P. Strobus.*

A specimen (Packet No. 11), of *P. pitya* on *Picea excelsa* from the herbarium of J. Lind was also examined.

Examination of Rostrup's Herbarium Specimens.

The critical examination of the above listed specimens from Rostrup's herbarium, identified as *Phoma pitya,* has revealed that a number of fungi have been included under this name. These include the following:

(1) *Sclerophoma* sp., very probably *S. pityophila* (Corda) v. Höhn., was found on *Pseudotsuga Douglasii, Abies pectinata, A. concolor, Pinus sylvestris* and *P. montana* in packets Nos. 5, 8, 9, 10.

(2) *Sclerophoma* sp., probably also *S. pityophila,* was found on *Picea excelsa* in packet No. 11. This was from the herbarium of J. Lind, Flora Suecica, collected and determined by I. Vlengel, Umeå, 1907.

(3) *Phomopsis Pseudotsugae* Wilson was identified by Dr Wilson and myself on *Abies pectinata* in packet No. 7.

(4) *Phomopsis Strobi* Syd. (13) was found on *Pinus sylvestris* and *P. montana* in packet No. 10.

(5) ?*Phomopsis juniperovora* Hahn was found on *Juniperus virginiana,* collected by Schrøder at Wedellsborg, May, 1898, in packet No. 6. *J. virginiana* is listed by Lind as a new host. Whether this fungus is identical physiologically with Hahn's cedar blight fungus which occurs as a parasite of young nursery seedlings of *Juniperus* and other coniferous genera in the United States (3, 4), can only be determined by cultural study and inoculation experiments.

(6) *Phomopsis* sp. was found on Douglas fir and balsam fir in packets Nos. 3, 4, 5 and 9. In Packet No. 5 a shoot of Douglas fir showed the *Phomopsis* at the base of the lesion and *Sclerophoma* fruiting beyond.

I was not able to examine any specimens identified by Rostrup as *Phoma pitya* on *Picea* as apparently diseased material of this host was not preserved. Nor was I able to examine specimens on larch, where Rostrup stated ((9), p. 569) that the fungus appeared to have spores somewhat shorter and more bent than those on the other coniferous hosts.

The pycnidium and spores of the *Phomopsis* sp. occurring in Rostrup's herbarium agree closely in shape with the drawings of apparently the same fungus which he figures as *Phoma pitya* in his text-book and reproduced here, Pl. XXII, fig. 2 *b*, *c*. The spore size of specimens of this particular fungus also agrees somewhat closely with that given by Rostrup in his brief description of *P. pitya* and with the measurements recorded on two of the herbarium packet labels. The *Phomopsis* sp. among the specimens of Rostrup also agrees closely as to shape and size with the "A" spores of *Phomopsis conorum* newly discovered in Great Britain and also found among collections of fungi on fresh material of Douglas fir made by Dr Wilson in Holland and Denmark in 1926 (12). Undoubtedly we are dealing with the same fungus as that previously observed by the Danish mycologist. I therefore propose to describe *Phomopsis conorum* more fully. It was identified and figured on conifer stems by Rostrup as *Phoma pitya*, but the published descriptions are somewhat inadequate (1, 5, 11, 12). In the light of our present knowledge of *Phoma pitya*, which has been identified as a *Sclerophoma* and provisionally named *Sclerophoma Magnusiana* (16), we know that Lind's combination *Phomopsis pitya* (6) is an error, being based upon a wrongly determined fungus. Furthermore, at least five different fungi were included under *Phoma pitya* by Rostrup, which makes it extremely difficult to determine the exact fungus Lind had in mind. I have not been able to obtain the actual type of *Phoma conorum* Sacc. on cone scales of spruce for examination, but from the descriptions given by Saccardo I assume that we are concerned with the same fungus on the trunks, branches and cones of conifers in Britain. The following emended description of this fungus is based upon fresh material collected in Scotland on the Douglas fir.

Phomopsis conorum (Sacc.) Died. in *Ann. Mycol.* IX (1911), 22.
Syn: *Phoma conorum* Sacc. in *Michelia*, II (1882), 615; *Syll. Fung.* XXII (1903), 903.
Phomopsis conorum (Sacc.) v. Höhn; var. *naviculispora* Trav.
Phomopsis pitya (Sacc.) Lind, pro parte; non *Phoma pitya* Sacc.

Pycnidia scattered or aggregate, ectostromatic, arising within and seated upon the upper layers of the cortex, among the cells of which the fruit-body remains incorporated, becoming only partially erumpent when the stromata rupture the epidermis (Pl. XXIII, fig. 1); black, carbonaceous, cone-shaped, lenticular, or somewhat globular, ostiole protruding; stromata simple, with a single locule, or compound, cavity tending to be divided irregularly by pseudopartitions, ·3–2·0 × ·2–·4 mm.; walls thin, with a thickened layer of fuligineous pseudoparenchymatous tissue above. Both "A" and "B" spores present (Pl. XXIII, fig. 1); "A" spores unicellular, hyaline, generally, spindle-shaped with acute or subacute extremities, or acute at only one extremity, rarely becoming elliptic, with gently rounded extremities, 6·5–13 × 2·5–4μ, commonly 9–11 × 3–3·5μ with one, two or three guttules (Pl. XXIII, fig. 2); "B" spores hyaline, continuous, filamentous, pronouncedly curved, hamate or sickle-shaped, 10–32 × 1μ, commonly 16–24 × 1μ (Pl. XXIII, fig. 3); intermediate spores occasionally found, very irregular in shape, attenuated, approaching the scolecosporic type, 14–18 × 1·5–2μ (Pl. XXIII, fig. 4); sporophores deeply staining, flexuous, tapering to acute extremities, occasionally branched, persistent, arising from the hymenium lining the cavity; both types of spores produced approximately on the same type of sporophore, 8–20μ long (Pl. XXIII, figs. 5, 6). The spores are exuded in creamy-white or yellowish tendrils.

"A" and "B" spores produced from monospore cultures on Douglas fir stems agree in size and shape with those obtained in nature.

Saccardo recorded it on the scales of fallen cones of *Abies* in France, Germany and Italy, and on the cone scales of *Abies excelsa* in Britain; it also occurs on dead branches and leaves of *Pseudotsuga Douglasii*, and on living branches and leaves of *Picea Sitchensis* and *Pinus Strobus* in Britain; on branches of *Pseudotsuga Douglasii* and *Abies balsamea* in Denmark and *Pseudotsuga Douglasii* in Holland.

Dr Wilson collected the fungus in 1920 on cone scales of *Picea excelsa*, Keir, Sterlingshire, Scotland. Morphologically it is similar to the forms occurring on conifer stems and leaves.

Other collections have been made by me in 1926 as follows: in Scotland; on *Pseudotsuga Douglasii*—nursery seedlings, Tulliallan, Fifeshire, No. 43,920, 26, 27, 28, 29, 32; dead branch, Bowmont Forest, Kelso, Roxburghshire, No. 43,922; nursery seedlings, Glentress, Peeblesshire, No. 43,943, 44, 62; on *Picea sitchensis*—nursery seedlings, Tulliallan, No. 43,917; nursery seedlings, Glentress, No. 43,946; in Wales, on *Pseudotsuga Douglasii*—dead branch, Lake Vyrnwy, Montgomery County, No. 43,963; by Dr Wilson in Denmark, on *P. Douglasii*—young nursery seedling, Lyngby, No. 43,959; in Holland, on *P. Douglasii*—young nursery transplant, Schovenhorst, No. 43,960.

In 1928, *P. conorum* was identified on material of young plantation stock of Sitka spruce received from Mr J. S. L. Waldie collected by him near Oxford. A dead suppressed twenty-year-old tree of *Pinus Strobus* at Glentress, Peeblesshire, No. 43,980 was found heavily infected with the fungus.

Phomopsis conorum has also been identified as similar morphologically to specimens of a *Phomopsis* sp. identified by E. Rostrup in Denmark as *Phoma pitya* on *Pseudotsuga Douglasii* (Pl. XXII, fig. 2)—Funen, Broholm, June, 1883, collected by E. R.; Funen, Glorup, September, 1889; Funen, Glorup, May 24th (c.?), collected by E. R.; on *Abies balsamea*—Jutland, Holt Plantage, July, 1883, collected by H. Sehested. Measurements of the "A" spores of these collections, showed in each specimen a range of 6·5–13 × 2·5–4μ, commonly 9–11 × 3–3·5μ. Rostrup gives the measurements as 10–13 × 4–5μ ((9), p. 567). On the herbarium specimen labels somewhat similar measurements were recorded by him of 9–13 × 3·5μ (Pl. XXII, fig. 2 *c*). "B" spores were not found in the pycnidia examined of the above material. These, however, may occur and their presence probably will be ascertained upon further research. Both "A" and "B" spores were found in fresh material of *P. conorum* collected by Wilson (No. 43,959) at Lyngby, Denmark, which agree in size with those described from Scotland, the range of the "A" spores is 6·5–13 × 2·5–4μ, commonly 9–11 × 3–3·5μ. Intergrading spores such as described for the British collections were also observed in this Danish material.

Parasitism of *Phomopsis conorum*.

As has been previously pointed out, both Rostrup and Lind regarded *Phoma pitya* as a definite parasite but they produced no actual experimental evidence to substantiate this belief. Fabricius (2) very recently drew attention to Rostrup's earlier observations of *P. pitya* as a parasite of Norway spruce. He cites the common occurrence of the fungus but is of the opinion that the organism is only saprophytic, and one which follows

the ravages of frost, where it becomes somewhat parasitic. He points out the close relation between *Phomopsis Pseudotsugae* and *Phoma pitya*. The writer's observations in Great Britain would lead him to believe that *Phomopsis conorum* under certain conditions might be parasitic to some extent. Where the organism was found in coniferous nurseries in Scotland, it was apparently associated with frost injury among young seedlings. Preliminary inoculations with single spore strains of *Phomopsis conorum* on Douglas fir have produced only negative results both in very young and older healthy tissue of *Pseudotsuga Douglasii*.

Relation between *Phomopsis conorum* and *P. Pseudotsugae*.

Phomopsis conorum is important in that it may be superficially confused with *P. Pseudotsugae* (15) to which the *Phomopsis* disease of conifers has been attributed, unless a critical examination is made. Morphologically the two *Phomopsis* species are quite distinct. *P. Pseudotsugae* produces an elliptic-fusoid type of "A" spore with obtuse extremities which differ in size and shape from the distinctly fusoid spores of *P. conorum*. The "A" spores of *P. Pseudotsugae* measure $4{\cdot}5–8{\cdot}5 \times 2–4\mu$. Although numerous fruiting bodies of *P. Pseudotsugae* grown on different artificial media, and a large number of freshly collected specimens of the fungus have been examined during the last five years, the filiform type of "B" spore has never been observed. Physiologically, the two species of *Phomopsis* are also quite distinct. Cultural differential studies have been made which will be reported upon later, together with results of artificial inoculation experiments. Preliminary inoculation experiments with *P. Pseudotsugae* performed by me in collaboration with Dr Wilson have yielded a high percentage of positive results, indicating it to be a true parasite of the Douglas fir, while inoculation results so far indicate that *P. conorum* is a saprophyte, but possibly weakly parasitic under certain host conditions. *P. conorum* has never been observed associated with a definite canker on the larger stems and trunks of Douglas fir, such as that reported by Wilson (15) for *P. Pseudotsugae*.

Summary.

Phomopsis conorum on the shoots of Douglas fir (*Pseudotsuga Douglasii*) is recorded for the first time from Great Britain. Unless a critical examination is made this *Phomopsis* may be easily confused with *Phomopsis Pseudotsugae* to which the *Phomopsis* disease of Douglas fir and other conifers has been previously attributed.

A *Phomopsis* sp. has also been discovered among the herbarium specimens on various conifers, identified by Rostrup as *Phoma pitya* Sacc., which bears a strong morphological resemblance to *Phomopsis conorum* from Great Britain. The type of *Phoma pitya* Sacc. has been examined and proves to be a typical *Sclerophoma* (*S. Magnusiana*).

A full description of *Phomopsis conorum* is given based on fresh material of Douglas fir from Scotland. Fresh collections of the fungus are also reported from Wales and England, Holland, and Denmark. *Picea*, *Pinus* and *Abies* are other hosts for the organism.

P. conorum differs from *P. Pseudotsugae* both morphologically and physiologically. There are distinct cultural differences. Preliminary inoculation experiments with *P. conorum* indicate it to be only a saprophyte, while inoculation experiments with *P. Pseudotsugae* have shown it to be a true parasite. *P. conorum* has not been observed associated with a definite branch and trunk canker of the Douglas fir, such as is reported for *P. Pseudotsugae*.

REFERENCES.

(1) Diedicke, H. Die Gattung *Phomopsis*. Ann. Mycol. IX (1911), 22.
(2) Fabricius, O. Douglas- og Sitkagran. Saertryk af Dansk Skovforenings Tidsskr. (1926).
(3) Hahn, G. G. *Phomopsis juniperovora*, a new species causing blight of nursery cedars. Phytopathology, X (1920), 249–253.
(4) —— *Phomopsis juniperovora* and closely related strains on conifers. *Loc. cit.* XVI (1926), 899–914.
(5) Höhnel, F. von. Erste vorläufige Mitteilung mykologischer Ergebnisse. Ber. Deutsche Bot. Gesell. XXX (1917), 255.
(6) Lind, J. Danish Fungi, p. 421. 1913.
(7) Rostrup, E. Beretninger om Undersøgelser, foretagne i 1884 og 1885 ifølge Finansministeriets Foranstaltning, angaaende Snyltesvampeangreb paa Naaletraeer, saerligtde forskellige Fyrrearter, paa alle Statsskovdistrikterne i Jylland. 1885.
(8) —— Undersøgelser oyer Snyltesvampes Angreb paa Skovträer i 1883–1888. Tidsskr. f. Skovbrug, XII (1890), 175–238. Summary in Bot. Centralbl. XLIII (1890), 353–6.
(9) —— Plantepatologi. 1902.
(10) —— Bornholms svampe. Bot. Tidsskr. XXVII (1906), 371–9.
(11) Saccardo, P. A. *Phoma conorum* Sacc. Fungi Gallici. Michelia, II (1882), 615.
(12) —— Sylloge Fungorum, III (1884), 150; XXII (1913), 903.
(13) Sydow, H. and Petrak, F. *Phomopsis Strobi* Syd. nov. spec. Ein Beitrag zur Kenntnis der Pilzflora Nordamerikas, insbesondere der Nordwestlichen Staaten. Ann. Mycol. XX (1922), 204.
(14) Wilson, M. A new species of *Phomopsis* on the Douglas fir. Trans. and Proc. Bot. Soc. Edinburgh, XXVIII (1920), 47–49.
(15) —— The *Phomopsis* disease of conifers. Bull. Forestry Commission, No. 6 (1925).
(16) Wilson, M. and Hahn, G. G. The identity of *Phoma pitya* Sacc., *Phoma abietina* Hart. and their relation to *Phomopsis Pseudotsugae* Wilson. Trans. Brit. Mycol. Soc. XIII (1928), 261.

DESCRIPTION OF PLATES XXII, XXIII.

All the figures in Plates XXII and XXIII are of *Phomopsis conorum* (Sacc.) Died.

PLATE XXII.

Fig. 1. Pycnidium in section showing fruit body only partially erumpent and incorporated among the cells of the upper layers of the cortex.
Fig. 2. A reproduction of the figure of *Phoma pitya* Sacc. given by Rostrup; (*a*) diseased shoot of Douglas fir with fungus fructifications; (*b*) pycnidium of the fungus showing the fruit body as being only partially erumpent; (*c*) spores.

PLATE XXIII.

All figures excepting Fig. 1 are ×1000.

Fig. 1. Pycnidium producing both "A" and "B" spores. ×200.
Fig. 2. "A" spores.
Fig. 3. "B" spores, showing attachment to sporophores. A branched sporophore is shown.
Fig. 4. Intermediate spores.
Fig. 5. Typical sporophores of "A" spores.
Fig. 6. Typical sporophores of "B" spores.

THE PHYSALOSPORA DISEASE OF THE BASKET WILLOW*.

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(With Plates XXIV—XXVII.)

Introduction.

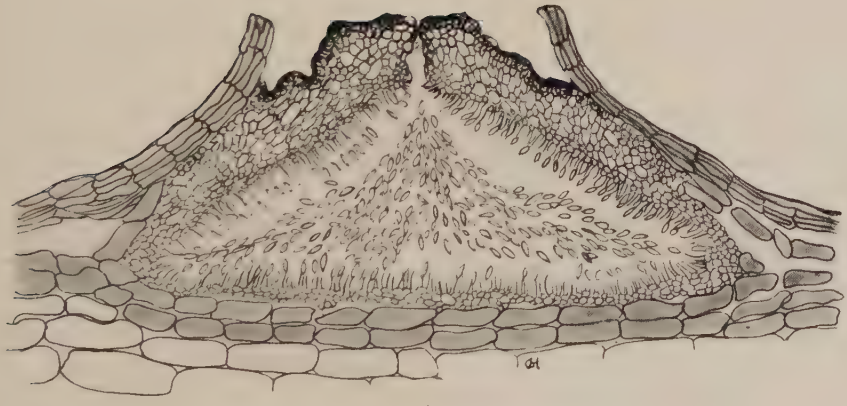
Little serious attention has been given in this country to fungus diseases of the Basket Willow. Though rusts of the genus *Melampsora* are well known as causing cankers on the rods used in the basket-making industry, no critical work appears to have been done on the *Physalospora* disease, which was attributed by Johnson (7) to *Physalospora* (*Botryosphaeria*) *gregaria* Sacc. and by Massee (8) to *Botryosphaeria gregaria* (Sacc.). Up to the present the fungus causing the disease has been considered as a wound parasite only, or as secondary, following a primary one such as *Fusicladium saliciperdum*, and rarely causing any direct damage in the field. For example it has been stated (1) that "large cankerous growths only develop in spring when the rods are standing in the pit."

As my preliminary observations on this disease did not agree with the previous work it was decided to investigate the life history and bionomics of the parasite in further detail.

In the present paper it is shown that the causal organism may be regarded, provisionally at least, as a species of *Physalospora*,

* Approved as part of a Thesis for the degree of Ph.D. in the University of London.

2



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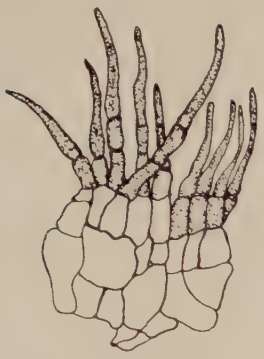
PHOMOPSIS CONORUM (SACC.) DIED.



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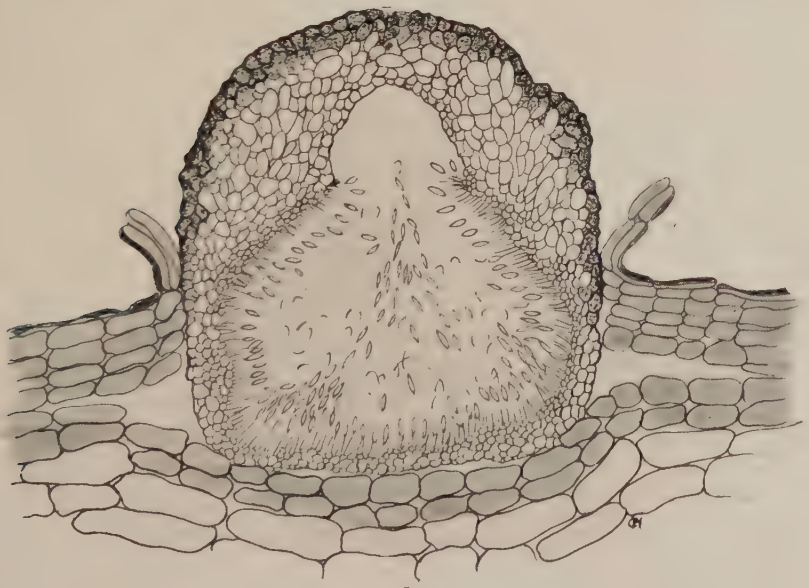

1

PHOMOPSIS CONORUM (SACC.) DIED.

but not that previously recorded in this country, and that it possesses a conidial stage of the *Gloeosporium* type which also appears to have escaped notice here. Observations and experiments show that it attacks the leaves and growing tips of the shoots directly and that the cankers on the stem arise as a direct result of the previous infection of the leaves.

Symptoms of the Disease.

The presence of the disease is shown by the following symptoms:

1. Blackening of the leaves.
2. Formation of lesions or "cankers" on the rods.
3. "Die-back" of the growing tips.

1. *The effect on the leaves.*

The symptoms on the leaves first become evident towards the end of May when the young rods are about two feet or more high. The varieties which are most commonly attacked are *Salix alba* vars. *vitellina* and *cardinalis*, *Salix americana* and certain ornamental willows of the "Weeper" class.

In the early stages small blackened areas occur on the lamina beginning from either the margin or tip and extending towards the mid-rib or down towards the petiole. The tissues on either one or both sides of the mid-rib may be affected on the same leaf. A characteristic effect is produced when the upper half of the lamina is affected; the blackened area extends downwards in the shape of a wedge and the upper blackened half of the lamina bends sharply down at right angles. All stages can be seen from small spots a few millimetres in diameter to larger areas involving the whole of the lamina and petiole. The smaller areas are usually roughly rectangular in outline, being bounded by the veins (Pl. XXVI, fig. 1).

The leaf, after blackening, droops, becomes dry and shrivelled but may remain attached to the stem. Although in autumn the lamina breaks away, the base of the petiole often remains attached to the stem throughout the winter. The symptoms on the leaves differ from those of the Water-mark disease of the Cricket Bat Willow described by Day (4), in which all the leaves on an affected branch wilt simultaneously, owing to the death of the branch as a whole. In the Black Canker disease here dealt with each leaf is itself attacked independently.

2. *The effect on the rods.*

The effect of the disease on the rods is the formation of slight lesions or definite cankers. These may take the form of small shield-shaped discoloured areas 2–3 cm. in length or of large deep-seated cankers 5–8 cm. or more in length. It is a

marked feature that these lesions occur almost invariably at the nodes. In plantations of *Salix alba* var. *vitellina* all intermediate stages have been seen from a diseased petiole joining a healthy stem to a similar petiole joining a mature lesion. So severe may be the attack that on a few inches of rod as many as three lesions may sometimes be observed at successive nodes (Pl. XXIV, fig. 2).

The effect on the rods depends on the time of year at which infection takes place. Early in the season, small shield-shaped lesions are formed and there is little or no tissue collapse to be seen externally. As the season progresses and considerable growth of the rod takes place large deep-seated cankers may result (Pl. XXIV, fig. 1). Such cankers become considerably elongated and there is a decided flattening or sinking in of the surface. The epidermis and outer part of the cortex eventually become cracked exposing the bast fibres, and in still more advanced stages the wood itself becomes visible. The cankered rods are of course useless for basket-making and even in the field they not infrequently break at the point of injury.

Microscopical examination of sections of the lesions show that the phloem and the cambium are the tissues which are most severely affected (Pl. XXVII, fig. 1). For a distance of several millimetres above and below the external canker the phloem is seen to be discoloured. A few of the wood vessels become blocked with gum, and the primary xylem and medullary rays are also coloured brown.

Sections cut nearer the centre of the canker show a flattening and sinking due to the collapse of the phloem and cortex, while the browning of the wood vessels and medullary rays is more pronounced. Owing to the collapse and disintegration of the soft bast the hard bast fibres are in contact with the surface of the wood (Pl. XXVII, fig. 1).

Sections through the actual centre of the canker show the killing of the axillary bud tissues and a still deeper infiltration of the wood vessels and medullary rays with gum. Since the cambium immediately below the affected tissues is killed, the production of new wood can take place only around the margin, thus accentuating the flattening brought about by the collapse of the phloem. The host apparently attempts to check the extension of the fungus by the formation of a layer of suberised tissue extending from the cambium to the epidermis. This protective layer is clearly seen on staining the sections with Sudan III. However, the reaction of the host to the parasite depends on the time of the year at which infection takes place. With the successful development and functioning of the protective layer, and the heavy infiltration of the wood vessels

and medullary rays with gum the diseased tissue is effectively isolated and frequently disappears, leaving the exposed wood and callused edges of the bark. On the other hand, if conditions favour the parasite it can progress so rapidly that the host is unable to form the protective layer and the rod may become completely girdled.

3. *Death of the tips of the rods.*

In addition to the blackened leaves and stem lesions die-back from the tips of the rods is frequent. The affected part may be at the apex of the main stem or of a lateral branch. In the main stem it is the succulent portion at the top, 6–8 inches long, which is affected. The tip bends over, suggesting very strongly the Wither Tip of plum trees caused by *Monilia cinerea* (Pl. XXVI, fig. 2).

It may be emphasized here that the die-back is due to infection at the very tip or a short distance behind it and subsequent growth of the fungus downwards. It is not due to the formation of a canker some distance below the tip and the consequent cutting off of the supply of sap, although this may also occasionally occur. *Salix americana* is particularly susceptible to this form of attack. The most serious aspect of the die-back is seen when the tips of young rods from 12–18 inches in height are attacked (Pl. XXVI, fig. 2). Young lateral growths may similarly die-back, and on reaching the main stem the fungus may form a canker.

These three types of injury—the blackening of the leaves, the lesions on the rods, and die-back of the shoot extremities—appeared from their mode of occurrence in nature to be intimately connected. It seemed probable that a parasite was at work which could attack tender portions of the plant, such as the leaves and growing tips, and was capable of growing from these down into more mature tissue, forming stem lesions and causing die-back; and investigation has now proved that this is so.

The Fungus Associated with the Disease.

Both perithecial and conidial fructifications occur on the stem lesions. The conidial stage is more evident in the early summer on the young lesions, when the minute, brick-red or pink spore-masses are plainly visible to the naked eye. Microscopical examination shows that the conidia are of the typical *Gloeosporium* type borne in an acervulus. Each acervulus consists of a stromatic mass of mycelial tissue which ruptures the epidermis at maturity, exposing the pink spore masses (Pl. XXVII, fig. 5). The acervuli are 0·3 mm. to 0·7 mm. in diameter, sometimes confluent and often arranged concentrically.

The conidia are one-celled, hyaline, or with a faint greenish tinge, and are pale pink to colourless in mass. They are ellipsoidal to ovate or cylindrical, straight or slightly curved, and frequently slightly narrowed in the centre. They are most frequently hemispherical at one end and slightly narrowed towards the point of attachment at the opposite end, but occasionally both ends may be rounded. The contents are granular and surround either 1–2 large vacuoles or one large oil drop at each end. The conidia measure 12·5–21·5 × 4–7μ, the average size being 17·5 × 6·5μ. They are borne at the tips of short flexuous conidiophores, which are of varying diameter, hyaline, sooty at the base, usually uniseptate, measuring 25–35 × 3·5–5μ, and arising from a stromatic mass of mycelium situated immediately below the epidermis (Pl. XXVII, figs. 3, 5).

The form of fructification most commonly met with on the stem lesions is the perithecium. The perithecia appear later than the acervuli: the stroma having borne an acervulus now bears aggregate perithecia, which can be found throughout the latter part of the season. Both perithecia and acervuli may occur on the same lesion but the former can easily be distinguished with the naked eye owing to their being more minute and more closely aggregated. Examined microscopically the perithecia are seen to be globose to flask-shaped, each with a short neck.

Although the perithecia may occur singly they are more usually aggregated, and therefore appear as if formed in a stroma; and, in a single transverse section of such a stroma four to five perithecia may be seen, those in the centre being considerably compressed laterally (Pl. XXV, fig. 1). Typical perithecia measure 140–200μ in diameter. They contain numbers of fasciculate, club-shaped asci measuring 65–70 (up to 86) × 10–11μ, together with slender, filiform paraphyses 1·5–2μ in diameter (Pl. XXVII, fig. 6). The paraphyses are plainly visible when an immature perithecium is crushed in water under a cover slip as slender, whip-like processes, projecting above the asci; they are not seen in a mature perithecium.

The asci are distinctly swollen at the base and the upper portions of their walls are considerably thickened leaving a narrow channel for the extrusion of the spores. Each ascus contains eight ascospores arranged more or less distichously. The ascospores are one-celled, hyaline, oblong to ellipsoidal, sometimes slightly curved. The contents are coarsely granular and usually enclose a large central vacuole. The spores measure 14–17 × 5–6μ (Pl. XXVII, fig. 6).

Neither acervuli nor perithecia have been found by the writer on the leaves and only occasionally have they been seen on the withered tips of the rods.

Isolation of the Fungus.

The fungus was readily isolated and pure cultures obtained by the following methods:

1. By pouring malt agar plates of suspensions of conidia and of ascospores.

2. By planting out on solidified agar plates small pieces of diseased tissue from below the epidermis of a lesion and from the base of a withered tip.

3. The fungus was also isolated from the diseased lamina and petiole. A leaf with a blackened area was washed with a solution of mercuric chloride followed by sterile water. Small pieces of the diseased portion were then removed aseptically and planted on a plate of solidified malt agar. From these a pure culture of the fungus was eventually obtained.

The pure cultures obtained from the diseased tissue of the leaves and withered tips were identical with those derived from single conidia and single ascospores obtained from the fructifications on the stem lesions, thus proving the presence of the pathogen in those tissues. Moreover, in these cultures perithecia containing ascospores identical with those occurring in nature eventually developed.

Cultural Characteristics.

(*a*) *Germination of ascospores and conidia.*

In hanging drops of sterile water at room temperature, both ascospores and conidia germinate in from five to six hours. The ascospores increase slightly in size, frequently become one-septate and produce from one to four germ-tubes. They may produce germ-tubes developing only into mycelium, or a single short germ-tube with a conidium at its apex, or they may bud off conidia direct without the formation of a germ-tube. In sterile water appressoria are formed abundantly after germination. These may be terminal, intercalary, or borne at the ends of short branches occurring at intervals along a hypha. They are dark brown, frequently with a hyaline central area, spherical to ovoid, typically $10{\cdot}5 \times 7\mu$ (Pl. XXVII, figs. 3, 4). They develop further by the production of a minute peg-like process which becomes continued as a secondary hypha. The conidia usually germinate by producing two germ-tubes from which secondary conidia are budded off, and appressoria are also readily produced.

Germinating conidia are not readily washed off the surface of a cover slip, but no mucilaginous envelope can be seen in an Indian ink preparation.

(b) Growth in pure culture.

Pure cultures of the fungus were grown on malt extract agar, sterilised willow twigs, sterilised apple wood and sterilised potato slices.

Grown on malt extract agar slants the aerial mycelium is white but after two to three days minute greenish grey knots appear which later give the surface of the culture a greyish colour. Below the aerial mycelium a brilliant rose-madder colour is developed, which persists until the cultures dry up. This colour, which is very characteristic, appeared in all the malt agar cultures whether derived from ascospores, from conidia or from diseased tissue of the host plant. It is due more to the colour of the hyphae themselves than to staining of the substratum and appears to be insoluble in alcohol. Cultures derived directly from naturally occurring ascospores and conidia produce a vigorous growth with little or no formation of conidia. Where the mycelium is in contact with the side of the tube, dark greenish black sclerotial tissue appears; and in older cultures a crust of similar sclerotial tissue occurs on the shrunken agar at the lower end of the culture tube. In such cultures perithecia are formed in the sclerotial tissue and in the body of the substratum after six to seven weeks. They always occur in small aggregates embedded in a mass of stromatic tissue 1–2 mm. in diameter.

When individuals derived from a single ascospore or a conidium are grown on a film of malt extract agar in a Petri dish active sporulation takes place. The conidia are borne on the aerial mycelium either singly or in groups of from two to four, and acervuli bearing colourless to pink spore masses appear on the surface of the substratum. In such individuals mycelial growth is much reduced, and a considerable amount of sclerotial tissue is produced. Mono-conidial cultures from these conidia continue to produce conidia-forming individuals actively. Strains producing a vigorous mycelial growth and perithecia, when subcultured for two, three or more generations, exhibit remarkably sudden variations in character. The faculty of forming vigorous mycelium and perithecia is lost, mycelial growth is restricted and the surface of the substratum becomes covered with sclerotial tissue on which abundant acervuli with pink conidial masses are borne. Occasionally individuals occur which are almost completely sterile, with a dark greenish black mycelium growing for the most part below the surface of the agar. In many of the cultures producing a thick sclerotial crust on the surface of the agar, minute spherical bodies of sclerotial tissue appear, as with cultures of *Colletotrichum*

atramentarium on the same medium. The reason for these sudden variations is not clear; they do not appear to be due entirely to strain or to varying conditions of moisture and nourishment. An individual on an agar plate producing abundant mycelium but no conidia may be induced to form them when three to four days old by removing a piece of agar from the centre. Active conidial formation with the production of sclerotial tissue then occurs round the cut edges of the agar. Repeated transference of mycelium and single spores from an actively conidia-forming individual to rich media, has failed to induce the mycelial character and perithecial forming faculty. Similar behaviour in culture of the conidial forms of *Glomerella cingulata* (Stonem.) Spauld. & v. Sch. has been described by Dastur (3). Inoculation experiments show that these conidia-forming individuals with restricted mycelial growth are not so actively pathogenic as is the more normal type of individual producing a luxuriant growth of mycelium without the formation of conidia.

On sterilised willow twig there is, as a rule, no growth of aerial mycelium, but two or three weeks after inoculation acervuli burst through the bark, frequently accompanied by minute brush-like tufts of mycelium. Perithecia appear later among the acervuli. The rose or pink colour is more or less apparent when the fungus is grown on any of the artificial media used, with the exception of liquid media. Young lesions, split longitudinally and kept in a moist Petri dish sometimes develop this colour on account of the conidia germinating *in situ* and the mycelium growing over the cut surface.

In order to prove the connection between the perithecia and the *Gloeosporium* conidial stage, individuals derived both from a single conidium and a single ascospore obtained from naturally occurring lesions were grown on malt extract agar slants. In both these types of culture, whether derived from a single ascospore or a single conidium, perithecia appeared after six weeks. On germinating the ascospores on malt extract agar plates individuals were produced bearing abundant conidia. Both the conidia and the ascospores occurring in these cultures were identical with those occurring in nature. Moreover the cultures derived from a single ascospore and a single conidium behaved similarly throughout this investigation. The relation between the *Physalospora* and *Gloeosporium* stages of the fungus is thus established.

Systematic Position of the Causal Organism.

The fungus has apparently hitherto passed in this country under the name, first suggested by Johnson (7), of *Physalospora* (*Botryosphaeria*) *gregaria* Sacc. In Ireland, Johnson found two

associated conidial forms which he assumed were its imperfect stages and which he described under the names of *Tetradia salicicola* and *Macrodendrophoma salicicola*.

Neither of these two conidial forms has been found associated with the Black Canker of osiers in England. No mention is made by Johnson of a *Gloeosporium* on osiers nor is any reference made to an attack on the leaves and young succulent growths. Moreover, in the original description of *Physalospora gregaria* Sacc., as figured in Fung. Ital. Tab. 432, 1878, the ascospores measure 25–30 × 13–14μ, being thus nearly twice as large as those found by the present writer.

The connection between *P. gregaria* and the two conidial stages *Tetradia* and *Macrodendrophoma* was apparently not tested by cultural work so that it remains problematical. Unfortunately, Johnson's material is not available for comparison. *Physalospora gregaria* Sacc. has not been seen by me on any material during the investigation, and it seems very doubtful if the cankers on osiers in England hitherto described are indeed caused by that fungus.

Physalospora Salicis Fuckel, described as occurring on dead twigs of *Salix fragilis*, agrees more closely with the fungus described in this paper, but since its conidial stage is said by Fuckel to be *Phoma Salicis* it cannot be identical.

As the fungus did not appear to agree very closely with any described form, specimens were sent to Miss Wakefield at Kew, who kindly undertook a search through the herbarium material and through the descriptions in Saccardo of the species of *Physalospora* and *Botryosphaeria* occurring on *Salix*. With the exception of *Physalospora Salicis* Fuck. none agreed at all closely; nor did any of the recorded species of *Gloeosporium* and *Myxosporium* agree with the conidial stage.

After the work described in this paper had been carried out, a paper by Fukushi (6) giving an account of a willow canker in Japan, caused by a species of *Physalospora* having a *Gloeosporium* conidial stage, was brought to my notice. This fungus Fukushi described as a new species, *Physalospora Miyabeana*. It is described as follows:

"***Physalospora Miyabeana*** sp. nov.

Perithecia solitary or in small cluster, abundant, immersed in the host tissues, with the mouths slightly protruding, dark brown, globose, 100–170μ in diameter. Asci numerous, clavate, 55–57 × 11μ. Spores uniseriate or sub-distichous, one-celled, oblong-ellipsoidal, often slightly curved, granular at the ends, hyaline, 15–17 × 5·5–7μ. Paraphyses slender, 66 × 1·2μ.

Acervuli gregarious, erumpent, conidiophores crowded

30–45 × 4–6μ, bearing spores at the tips. Conidia unicellular, ellipsoidal or oblong-ellipsoidal, sometimes slightly curved, with rounded ends, hyaline, 13–23 × 3·8–6·8μ, mostly 17–19 × 4·5–6μ. Setae scattered round the acervuli on the leaf, straight, dark brown, septate, 40–55 × 3·7μ. Conidial masses light brick-red.

Forming cankers on the stem, or round spots on the leaf of *Salix purpurea* var. *angustifolia* Sapporo, Japan."

This is the only record found of a fungus, other than *Fusicladium saliciperdum*, directly attacking the leaves of the willow and also forming stem lesions; and its close similarity with the English willow canker fungus was at once apparent. A careful comparison, however, of the morphological characters of the conidial and perithecial stages reveals certain slight differences. The chief of these are the presence of setae and the non-flexuous character of the conidiophores in the *Gloeosporium* stage of the Japanese fungus, and the occurrence on the leaves of circular spots with concentric markings bearing acervuli. The almost invariable occurrence of the rose-madder or pink colour on artificial media and the ready formation of perithecia in malt agar cultures of the English fungus constitute a slight difference in cultural characteristics. In the opinion of Miss Wakefield, these differences are not, so far as can be seen at present, of sufficient importance to warrant the description of a new species, and the fungus is therefore included provisionally under *Physalospora Miyabeana* Fukushi; the grounds for so doing being the marked similarity between both the conidial and perfect stages of the two fungi and the general effect upon the host plant.

The further question as to the correct genus in which to place this fungus is a difficult one. The perithecia are so frequently and so markedly caespitose that it is not a typical *Physalospora*. On the other hand each perithecium has a distinct ostiole, occasionally even a short neck, and it is doubtful whether there is a true stroma such as is characteristic of *Botryosphaeria*. Until the structure and relations of the species included in these two genera and their allies are better understood, it seems wiser to retain the name used by Fukushi for the willow fungus. At the same time, however, the fact that this fungus has an imperfect stage of the *Gloeosporium* type and that its conidia produce appressoria when germinated in water is very interesting and suggestive. Edgerton (5) showed that such appressoria are characteristic of the species of *Gloeosporium* and *Colletotrichum* which belong to the genus *Glomerella*. Further, its cultural characteristics have many features in common with those of the conidial stage of *Glomerella cingulata* (Stonem.) Spauld. & v. Sch. The question arises, therefore, whether the

present fungus may not be related more closely to *Glomerella* than to *Physalospora*.

Inoculation Experiments.

1. *On woody tissue.*

These inoculations were made on "sets" of *Salix vitellina* growing in pots in a greenhouse, by making a small cut in the bark with a sterile scalpel and placing a small piece of a malt agar culture in the wound. The bark was then pressed down over the inoculum and the wound wrapped in tin foil and the whole painted over with paraffin wax. The controls consisted of similar wounds but without inoculum. The wrapping was removed after eight to ten days. Some of the sets were inoculated before planting and these, after planting, grew well and produced shoots and leaves normally. Whenever the inoculum was from a normal culture producing abundant mycelium, whether derived from conidia or ascospores, well-marked lesions resulted, on which acervuli bearing conidia were produced in about twenty-two days and mature perithecia after thirty-six days (Pl. XXV, fig. 5). Sections of these artificially produced lesions showed that the fungus had penetrated as far as the wood, and that for some distance above and below the external limits of the lesion the cortex and wood were discoloured. In the control sets no such discoloration occurred. Inoculations made with the conidia-bearing cultures did not take so readily. After two or three weeks only slightly blackened areas appeared round the wounds, and no acervuli were produced. It appears that such strains lose their pathogenic power to a considerable extent when active growth and perithecia-forming capacity is lost. Similar inoculations were made on sets of *Salix americana* and on *S. purpurea*; in both, lesions bearing acervuli were formed. From these inoculations conidia and ascospores, identical with those occurring on natural lesions, were produced. The fungus is thus shown to be a true pathogen capable of attacking healthy tissues and producing cankers typical of the disease as seen in nature.

2. *Leaf inoculations.*

(1) In a preliminary experiment small pieces of a malt agar culture of the fungus were placed on the upper surfaces of the leaves of a seedling of *Salix triandra*, which were then pricked through the inoculum with a sterile needle. The control leaves were similarly wounded without the inoculum; two leaves were inoculated and two were left as controls. The plant was then placed under a bell-jar at room temperature. After eight days

the inoculated leaves showed a considerable blackened area extending along the tissues on both sides of the mid-rib. The control leaves remained unaltered.

(2) Four pieces of a malt agar culture were placed on the upper surfaces of four leaves of a plant of *Salix vitellina* growing in a pot. On a control plant three pieces of sterile malt agar were placed on each of the three leaves. Each plant was placed under a bell-jar in a greenhouse. The surfaces of the leaves were unwounded. After four days the inoculated leaves were blackened for an area of about 1 cm. in diameter round the piece of inoculum, whereas the leaves on the control plant showed no discoloration.

(3) Suspensions of conidia in sterile water were placed on the surfaces of fresh willow leaves, whilst drops of sterile water were placed on leaves serving as controls. Both sets of leaves were then pricked through the film of liquid and incubated in a moist chamber at 25° C.

In the inoculated leaves small discoloured areas appeared round the wounds after eighteen hours, and this area gradually spread until the whole leaf had become discoloured. On one of the leaves, after seven days, concentrically arranged acervuli bearing pink spore masses appeared round the point of inoculation.

The control leaves remained fresh and green for three or four days and showed only slight discoloration due to natural death of the tissues after seven days.

Similar positive results were obtained using suspensions of conidia on the unwounded upper surfaces of leaves. On young leaves of *S. vitellina* discoloration at the point of inoculation occurred after forty hours at 25° C.

The germination of the conidia on the surface of the living leaf and penetration of the cuticle was observed as follows:

A suspension of conidia in sterile water was placed on the upper surface of a detached willow leaf which was then kept in a moist chamber at 25° C. for forty hours. After fixing in Farmer's fixative and placing in ninety-five per cent. alcohol until completely decolorised, the leaf was transferred to hot lacto-phenol until cleared, then stained for two to three minutes in cotton blue. After removing the excess stain by lacto-phenol, the germinated conidia could plainly be seen on the surface of the transparent leaf. It was observed that the conidia had often produced one or two germ tubes of varying lengths, at the distal ends of which a well-marked brown appressorium pressed closely to the surface of the leaf almost invariably occurred; the stain did not penetrate the leaf so that hyphal growth below the epidermis could not be traced. Occasionally

a germ-tube was observed growing down into a stoma, but there was no indication of any special chemotactic or other attraction towards the stomata. Stained microtomed sections of infected leaves showed that the cuticle is penetrated by a minute thread-like process protruded from the appressorium. This process swells out inside the upper wall of the epidermal cell in the form of a globular vesicle. It was also observed that a certain amount of swelling of the cell wall takes place at the point of infection (Pl. XXVII, fig. 2). Forty hours after inoculation at 25° C. mycelium can be seen within the leaf tissues. The hyphae measure from 2·3–3μ in diameter and are both inter- and intracellular.

These preliminary experiments on the severed leaf under artificial conditions showed that the product of the germinating conidia could penetrate the unbroken leaf cuticle and that the fungus could function as a parasite inside the leaf tissues.

(4) To confirm the foregoing, further inoculation experiments were carried out on sets of *S. vitellina* growing in pots; sets each with two or more shoots were chosen. Leaves and growing tips were inoculated by placing drops of a suspension of conidia in sterile water on the surface. The conidia were obtained either from ascospore-individuals on malt extract agar plates or from the first generation of conidia-individuals from ascospore cultures. On each plant one shoot was left as a control, being treated with sterile water instead of a suspension of conidia. On a few occasions the results with leaf inoculations were negative. This may be attributed to the difficulty of keeping a film of moisture on the surface when the leaves are at the angle at which they normally grow.

The two following inoculation experiments are typical of the results obtained:

(1) Willow set of *S. alba*, var. *vitellina* in pot. The top shoot No. 1 was used as a control, the remaining shoots Nos. 2, 3 and 4 were inoculated with a suspension of conidia in sterile water on the unwounded leaf surfaces and growing tips. The plant was then placed under a bell-jar in the laboratory. After four days the control shoot continued normal growth but on shoots Nos. 2, 3 and 4 the growing tips were blackened and dying back. On shoots Nos. 2 and 3 in which lengthening of the internodes had not taken place all the young leaves became involved. On shoot No. 4 one leaf was blackened half-way from its tip to the base of the petiole.

(2) Willow set of *S. vitellina* in pot. The top shoot No. 1 as control was treated with sterile water. Shoots Nos. 2, 3 and 4 were inoculated on leaves and growing tips with a suspension of conidia in sterile water. This plant was placed under a bell-jar and incubated at 25° C. for sixty-six hours. On the three

inoculated shoots sixteen points of infection occurred, including the three growing tips. After removal from the incubator the plant was placed in a greenhouse. The die-back from the growing tip continued and the blackened areas on the leaves continued to increase in size.

In this type of inoculation, positive results were almost invariably obtained on the growing tips, a result which can be attributed largely to the fact that in addition to the tissue being more delicate at that point, drops of liquid are readily held between the adjacent leaf surfaces. On the unfolded leaves the liquid is more likely to spread over the surface as a thin film and to become dried up.

The inoculated plants were afterwards kept under more or less normal conditions in the greenhouse. The shoots continued to die back until in some the main stem was reached. The inoculated leaves, though they died back as far as the base of the petiole, at this stage dropped off. From the inoculated leaves and blackened tips the pathogen was re-isolated and when inoculated into the woody stems produced typical lesions which eventually bore acervuli and perithecia identical with those occurring in nature.

In these experiments the material used consisted of rooted sets growing in pots. These sets, owing to restricted root development, did not produce such vigorous shoots as are produced naturally from stools and to this fact may perhaps be attributed the shedding of the inoculated leaves. A further series of inoculations was carried out on vigorously growing shoots removed from a stool of *Salix vitellina*, var. *basfordiensis* and placed in water. The leaves were inoculated with a suspension of conidia about 1 cm. from the base of the lamina and the mid-rib was pricked with a sterile needle at the point of inoculation. Six days after inoculation the diseased tissue had reached the petiole and after a further twelve days lesions bearing acervuli appeared on the main stem.

Similar experiments carried out on plants of *Salix purpurea* showed that infection does not normally occur when suspensions of conidia are placed on the unwounded leaf surfaces. When growing tips and leaf surfaces are pricked, however, infection does take place. Owing to its nature the leaf surface of *S. purpurea* is extremely difficult to wet, so that it does not normally become covered with a film of moisture as do other varieties. Canker is rarely seen in plantations of *S. purpurea*, though experiments show that when entry is obtained through wounds the fungus is actively parasitic. It may be that the observed natural immunity to canker enjoyed by *S. purpurea* is due to the peculiar nature of the leaf surface rather than to any inherent disease resistance capacity.

In addition to these inoculation experiments the progress of the fungus down the petiole into the stem has been observed in the field. Leaves of *Salix basfordiensis* and *S. vitellina* which had died back as far as the petiole were labelled at the beginning of June. Ten days later it was observed that frequently the diseased tissue had reached the main stem and that a lesion had been formed.

Pathogenicity.

As has previously been stated the fungus causing the Black Canker of the willow has been considered to be a secondary wound parasite only and that cankers develop on the rods only in the pit after the growing season.

Observations show, however, that the cankers are formed during the growing season and that such cankers become so protected by cork and gum that further elongation rarely takes place after the rod is cut. With the exception of Fukushi's paper there is no record of the willow canker fungus directly attacking leaves and growing tips.

Superficially, the symptoms of the disease on the leaves and on the young succulent shoots resemble those caused by the Willow Scab fungus, *Fusicladium saliciperdum* (Allesch. & Tub.) Tub. A description of this disease on *Salix alba* var. *vitellina pendula* in Holland was given in some detail by Miss Schwarz (9), who recorded *Fusicladium saliciperdum* as infecting the leaves and growing down the petiole into the main stem and there forming a lesion. It is further stated that on the lesions the perithecia of a *secondary* fungus, *Physalospora Salicis* Fuck., occur. This latter fungus is regarded as being a weak parasite following the attack of *Fusicladium saliciperdum*. Similar symptoms on leaves and growing tips have recently been recorded from Scotland (2), the causal organism here also being *Fusicladium saliciperdum*. So far as I have been able to ascertain *Fusicladium saliciperdum* is not of common occurrence in Somerset, and indeed, a single example has only recently been observed.

From the observations and inoculation experiments described it is seen that *Physalospora Miyabeana* can act as a virulent parasite of certain varieties of willow. It is capable of infecting the host plant directly through the leaves and growing tips without the intervention of wounds or of any other parasitic fungus. The primary attacks are confined to the leaves and young shoots. The product of the germinating ascospores and conidia can penetrate the cuticle directly and the resulting mycelium can pass down the petiole into the main stem or cause a die-back from the growing tip. All lesions examined occurred at the nodes, suggesting that the parasite had obtained

entry at that point. Perhaps the most serious aspect of the disease is to be seen when the growing tips are attacked under conditions favourable to the disease. This may occur at any time during the growing season and cause injury to the rods. When young rods, six to eight inches high, are so attacked the fungus may work down their entire length and enter the tissue of the parent stool (Pl. XXVI, fig. 2).

Control Measures.

The perithecia on the old lesions are the main source of infection in the spring. With the cutting of the rods in the winter this source of infection is largely removed. There remain, however, the perithecia on dead twigs lying on the ground and, where they occur, on rods left for "two year olds," which constitute the most serious source of infection. Attacks on the young rods have frequently been observed to begin in the vicinity of these two year old rods. With the production of acervuli arising from these primary infections the disease may reach epidemic proportions. No fungicides in common use are likely to have any sufficiently destructive effect on the perithecia and acervuli on the stem lesions, and since experiments and observations have shown that, in the normal course of events, the fungus can attack the host only through the leaves and young succulent tissue, the protection of these by a toxic film of fungicidal material is indicated as a means of controlling the disease on a field scale. Such a toxic film would be obtained by spraying with Bordeaux or Burgundy Mixture. In order to test the efficacy of Bordeaux Mixture the following experiment was carried out in the laboratory. Microscope cover slips were coated with a thin film of Bordeaux Mixture (4–4–50 formula) and allowed to dry. Suspensions of conidia in sterile water were placed on the cover slips and mounted as hanging drop cultures. Similar control hanging drops were made without the film of Bordeaux Mixture. The cultures were then examined after incubating for twenty-four hours at 25° C. In the control cultures the conidia germinated vigorously. The cover slips treated with Bordeaux Mixture were flooded with a dilute aqueous solution of methylene blue to render the conidia visible among the particles of Bordeaux Mixture, then gently washed with water and examined. The conidia could plainly be seen adhering to the surface of the cover slip but no germination had taken place.

Fresh leaves of *Salix vitellina* were similarly treated with Bordeaux Mixture. These and control leaves were inoculated by placing on their surfaces drops of a suspension of conidia in sterile water and incubating in a moist chamber for forty hours at 25° C. The control leaves then showed discoloured areas at the points of inoculation, whereas the Bordeaux-treated leaves

remained unaffected. Both sets of leaves were fixed, cleared with lacto-phenol and stained with cotton blue. The conidia had germinated on the control leaves with the production of germ-tubes and appressoria, but on those treated with Bordeaux Mixture the spores had not germinated and remained adhering to the surface. As a further test of the efficacy of Bordeaux Mixture in preventing infection, one leafy shoot of a willow set growing in a pot was sprayed and the remaining shoot left unsprayed. When dry, both shoots were treated with a suspension of conidia in sterile water on leaves and growing tips, and the plant placed in an incubator at 25° C. After forty hours all leaves and growing tips of the unsprayed shoot showed discoloured areas whereas on the sprayed shoot only one growing tip was affected. From these experiments it would appear that a film of Bordeaux Mixture on the surface of the leaves effectually prevents the germination of spores.

The control measure suggested would therefore consist of applications of a protective fungicide during the growth of the rods. It is suggested that the rods should be sprayed at intervals of about three weeks with Bordeaux Mixture until further spraying is no longer possible. Field trials are now being carried out by Mr Hutchinson and myself to test this method of control. In the propagation of the basket willow it is of course of the utmost importance that sets bearing lesions should not be planted.

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Summary.

1. This paper records the result of an investigation of the *Physalospora* disease of Basket Willows in the Somerset willow-growing district.

2. Symptoms of the disease are the blackening of the leaves, die-back of the young shoots and the formation of lesions or cankers on the rods.

3. No fructifications have been seen on the leaves, but perithecia of a species of *Physalospora* and acervuli of a species of *Gloeosporium* occur on the lesions on the rods.

4. The connection between these perithecial and conidial forms has been shown by cultural work, and the various cultural characteristics are described.

5. The ascospores and conidia germinate with the production of appressoria and are shown to be capable of infecting directly through the uninjured cuticle of leaves.

6. Inoculation experiments show that the fungus is actively parasitic, directly infecting leaves and growing tips, and afterwards growing downwards into the main stem.

7. The fungus is provisionally regarded as being not essentially different from *Physalospora Miyabeana* Fukushi, but the question of its having a greater affinity to the genus *Glomerella* arises, and remains to be settled by further work.

8. Control measures based on laboratory experiments are suggested. They consist of covering the leaves with a protective fungicidal layer rather than attempting to kill the perithecia and acervuli directly.

Addendum.

After the work on the *Physalospora* disease described in the above paper had been carried out, further attention was paid to the fungus *Fusicladium saliciperdum* (Allesch. & Tub.) Tub. occurring in this country. The symptoms of the *Physalospora* disease on the leaves superficially resemble those attributed to *F. saliciperdum* by workers in Holland (9) and Scotland (2), who state that a secondary parasite, *Physalospora* sp., occurs on the lesions primarily caused by *F. saliciperdum*. My observations have shown that, on foliage with typical symptoms of the disease, conidiophores of *F. saliciperdum* do not occur invariably and are confined typically to the central portion of the diseased tissue. Conidiophores of *F. saliciperdum* occur only when the disease has made considerable progress. They have not been observed in the initial stages of the attack.

Isolations made from the diseased tissue of a freshly attacked leaf yield *Physalospora Miyabeana* and, similarly, isolations made from the margin of diseased tissue bearing conidiophores of *F. saliciperdum* also yield *P. Miyabeana*. It would appear therefore that *P. Miyabeana* is invariably present in the diseased tissue and that *F. saliciperdum* occurs only occasionally and never at the margin.

Conidia of *F. saliciperdum* germinate readily and the fungus grows well as a saprophyte in pure culture.

Parallel inoculations were made on the wounded surfaces of living leaves of *Salix pentandra* with suspensions of conidia of *P. Miyabeana* and *F. saliciperdum*. No positive results were ever obtained with *F. saliciperdum* though the conidia were observed to have germinated readily, whereas, with *P. Miyabeana*

positive results were almost invariably obtained and typical symptoms of the disease were produced.

From these preliminary observations and experiments it appears that on the basket willow in Somerset *F. saliciperdum* cannot be regarded other than as a follower of *P. Miyabeana* and that it is in no way responsible for the symptoms of the disease on the leaves.

REFERENCES.

(1) Anon. Insect and Fungus Pests of Basket Willows. Min. of Agric. and Fisheries, Leaflet No. 301, London, 1918.
(2) Alcock, N. L. Successional Disease in Plants as shown in Willow Rods. Trans. Brit. Mycol. Soc. xi, 161.
(3) Dastur, J. F. *Glomerella cingulata* (Stoneman) Spauld. and v. Sch. and its conidial forms *Gloeosporium piperatum* E. and E. and *Colletotrichum nigrum* E. and Hals. on Chillies and *Carica Papaya*. Ann. Appl. Biol. vi (1919–20), 245–268.
(4) Day, W. R. The Watermark Disease of the Cricket Bat Willow (*Salix caerulea*). Oxford Forestry Memoirs, No. 3 (1924), 1.
(5) Edgerton, C. W. Some Anthracnoses. Bot. Gaz. xlv (1908), 403.
(6) Fukushi, T. A willow Canker Disease caused by *Physalospora Miyabeana* and its Conidial Form, *Gloeosporium*. Ann. Phyt. Soc. Japan, 1 (1921), 1–12.
(7) Johnson, T. Willow Canker—*Physalospora* (*Botryosphaeria*) *gregaria* Sacc. Proc. Roy. Dublin Soc. x (1904), 153–166.
(8) Massee, G. Diseases of Cultivated Plants and Trees, p. 174. 1910.
(9) Schwarz, M. B. Das Triebsterben und der Rindenbrand der Trauerweide. Mededeelingen, Phytopath. Lab. "Willie Commelin Scholten," v (1922), 34–49.

EXPLANATION OF PLATES XXIV—XXVII.

PLATE XXIV.

Fig. 1. Cankers caused by *Physalospora Miyabeana* as they appear on rods of *Salix triandra* after peeling.
Fig. 2. Shoot of *S. vitellina* var. *basfordiensis* showing lesion on the stem caused by infection through leaf.
Fig. 3. Leaves of *S. pentandra*, eight days after inoculation.

PLATE XXV.

Fig. 1. Cross-section of twig through canker showing a group of perithecia of *Physalospora Miyabeana*. × 65.
Fig. 2. Infected leaf and lesion on woody shoot on *Salix vitellina*.
Fig. 3. Pure culture of *P. Miyabeana* on malt extract agar showing sclerotial tissue and aggregate perithecia in the substratum.
Fig. 4. Shoot of *S. basfordiensis* naturally infected with *P. Miyabeana*.
Fig. 5. Set of *S. vitellina* showing result of inoculations into the bark of an internode after thirty-six days. Perithecia and acervuli both present.

PLATE XXVI.

Fig. 1. Leaves of *Salix vitellina* naturally infected with *Physalospora Miyabeana*.
Fig. 2. Stool of *S. vitellina* showing die-back of young shoots.

PLATE XXVII.

Fig. 1. Diagrammatic view of cross-sections of canker at three levels showing the effect of the parasite on the host tissues. × 750.
Fig. 2. Penetration of the outer wall of the epidermis of a leaf. × 750.
Fig. 3. Conidia and conidiophores of *Physalospora Miyabeana*.
Fig. 4. Germinating ascospores of *P. Miyabeana*.
Fig. 5. Section through an acervulus of *P. Miyabeana*.
Fig. 6. Asci, paraphysis, and ascospores of *P. Miyabeana*.

1

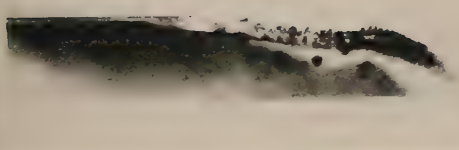
2

3

PHYSALOSPORA MIYABEANA FUK.

1

2



3

5

1

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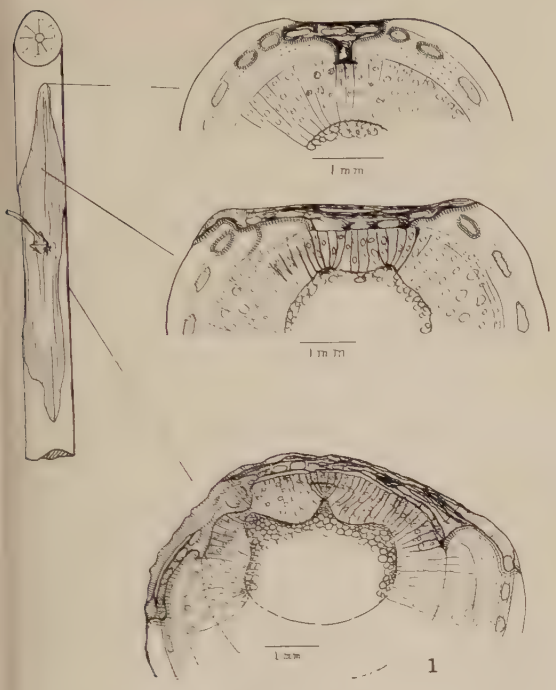
PHYSALOSPORA MIYABEANA FUK.



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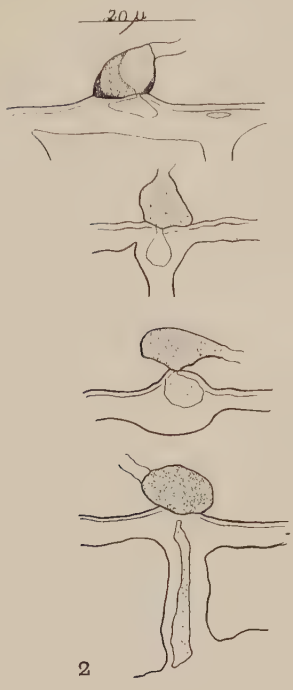

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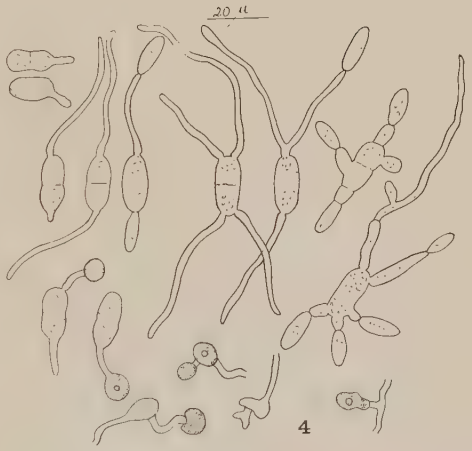

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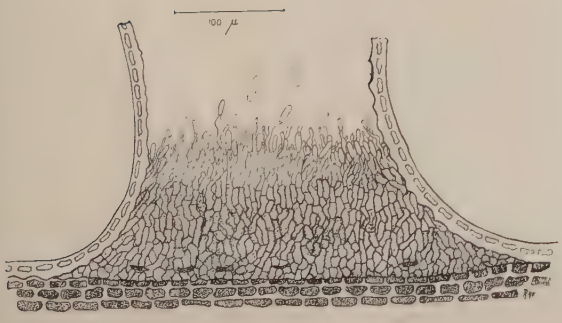

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6

THE AVIEMORE FORAY.

September 12th to 17th, 1927.

THE thirty-first Autumn Fungus Foray and Annual General Meeting took place at Aviemore during the week September 12th to 17th. The meeting was held in conjunction with the Scottish Cryptogamic Society, and by Monday evening a large party consisting of members of both Societies had assembled. As headquarters for the exhibition of specimens and the reading of papers the roomy hall of the British Legion had been secured. Here some preliminary exhibits were set out, including *Phallus imperialis* and *Flammula astragalina*, the latter brought from Dunkeld.

During the first three days plenty of scope for collecting was found in different parts of Rothiemurchus Forest. Those members who had arrived overnight spent Monday in exploring the outskirts of the Forest south of Aviemore. On Tuesday the whole party proceeded at once to the head of Loch an Eilean, thence working round the lake and so homeward again by a slightly different route. The following day the region near Coylumbridge was explored.

Members from more southern districts found much to interest them in the unfamiliar species encountered. For instance, birch trees in the neighbourhood of Aviemore were found to abound in *Fomes nigrescens*, the black form of *Fomes fomentarius*, which like the type form is never seen in the south. Again, Rothiemurchus yielded a number of species of stipitate Hydnums, as for instance *H. ferrugineum*, which was common, *H. compactum*, *H. fragile*, *H. graveolens*, *H. aurantiacum*, etc. These and some of the less usual Agarics, such as *Armillaria bulbigera* and *A. caligata*, *Lactarius aspideus*, *Leptonia euchroa* with its wonderful blue colour, and various of the larger Cortinarii, provided almost more work than could be easily covered, especially by those who were visiting the Highlands for the first time. It was of enormous help to the junior members to have Mr Rea and Dr Paul as ever-ready and willing sources of information.

On the Thursday quite new ground was broken by an excursion to Boat of Garten and Abernethy Forest. Here the larger fungi found were much the same as those in Rothiemurchus, but in far less quantity and less variety. On the other hand some interesting microfungi were obtained. On the open heath were *Chrysomyxa Empetri* and *Uromyces Orobi*, while here and there in the Forest were patches of *Vaccinium* infested with *Gibbera Vaccinii*. Other finds were *Synchytrium Succisae*,

Synchytrium aureum on *Cardamine*, and *Physoderma Menyanthis* on the Bog Bean.

Some interesting microfungi were found also on the following day (Friday). The main party worked the woods north of Aviemore, towards Carr Bridge, but a few members remained behind and explored the banks of the Spey, having regard especially to parasitic fungi. Here Dr Butler found *Cercosporella Filicis-foeminae* (Bres.) v. Hoehn., growing on fronds of the Lady Fern. This species, which is new to Britain, bears a striking resemblance in habit to species of *Milesina*, the fern-rusts. The most exciting find by the members who worked in the woods was *Cordyceps capitata*, a fine clump of which was discovered by Mrs Alcock towards the end of the afternoon.

During the week the usual business of the Autumn Foray was transacted. On Tuesday evening, at 8.45 p.m., Dr Butler delivered his Presidential Address, "The Development of Economic Mycology in the Empire Overseas." On Wednesday evening, September 14th, the Annual General Meeting was held. Officers for 1928 were elected as follows: President, Professor Dame Helen Gwynne-Vaughan; Vice-Presidents, Dr Butler and Mr R. Paulson; elected members of Council, Dr W. Brown and Mr G. N. Bunyard, to replace Mr Buddin and Mr F. G. Gould, who retired under the rules. The other officers remain as before. Dr Malcolm Wilson was chosen to represent the Society at the meeting of the British Association to be held in Glasgow in 1928. For the Autumn Foray in 1928, the Arundel district was selected.

On the Thursday evening, Dr Malcolm Wilson gave a paper on "The Life-history of *Milesina Kriegeriana* and its occurrence in Britain," and Dr G. G. Hahn of the United States Department of Agriculture followed with "Species of *Phomopsis* occurring on Conifers and their distinction in culture."

At the close of the week, on the Friday evening, Mr Rea commented on the various fungi that had been found during the week, after which hearty votes of thanks were passed to the landowners who had given permission for their estates to be visited, and especially to Mr Rupert Smith, secretary of the Scottish Cryptogamic Society, who had been responsible for the arrangements for the joint meeting.

The following list records all the species found. For assistance in compilation the Secretary is indebted to all the members present, and more especially to Mr Rea, Mr Ramsbottom, Mr E. W. Mason (Pyrenomycetes), Mr Pearson and Mr Buddin.

Complete List of Species gathered during the Foray.

A. = Abernethy Forest; *B.* = Birch wood west of village of Aviemore; *C.* = Woods north of Aviemore; *Av.* = Aviemore village and north bank of River Spey; *S.* = Woods near sawmill, south of Aviemore and river Spey; *R.* = Rothiemurchus Forest.

Amanita porphyria (A. & S.) Fr., *B.*, *R.*, *A.*, *C.*, mappa (Batsch) Fr., *B.*, muscaria (Linn.) Fr., *B.*, *R.*, *A.*, *C.*, rubescens (Pers.) Fr., *B.*, *S.*, *R.*, *A.*

Amanitopsis vaginata (Bull.) Roze, *S.*, *R.*, fulva (Schaeff.) W. G. Sm., *R.*

Lepiota rhacodes (Vitt.) Fr., *R.*, felina (Pers.) Fr., *R.*, granulosa (Batsch) Fr., *R.*, *A.*, amaianthina (Scop.) Fr., *S.*, *R.*, cinnabarina (A. & S.) Fr., *R.*, *A.*, carcharias (Pers.) Fr., *R.*

Armillaria bulbigera (A. & S.) Fr., *R.*, caligata (Viv.) Fr., *R.*, *A.*, mellea (Vahl) Fr., *B.*, *R.*

Tricholoma equestre (Linn.) Fr., *R.*, coryphaeum Fr., *R.*, sejunctum (Sow.) Fr., *B.*, *R.*, portentosum Fr., *C.*, spermaticum (Paul.) Fr., *R.*, fulvum (DC.) Fr., *R.*, albobrunneum (Pers.) Fr., *C.*, rutilans (Schaeff.) Fr., *S.*, *R.*, *C.*, *A.*, decorum (Fr.) Quél., *R.*, imbricatum Fr., *R.*, vaccinum (Pers.) Fr., *R.*, argyraceum (Bull.) Fr., *A.*, *R.*, saponaceum Fr., *A.*, *R.*, *C.*, and var. squamosum Cooke, *A.*, civile Fr., *R.*, cinerascens (Bull. non Fr.) Quél., *R.*, *A.*

Russula nigricans (Bull.) Fr., *R.*, densifolia (Secr.) Gill., *R.*, lepida Fr., *S.*, furcata (Pers.) Fr., *R.*, *A.*, *C.*, heterophylla Fr., *C.*, fellea Fr., *R.*, drimeia Cooke, *R.*, *A.*, and var. Queletii (Fr.) Bataille, *R.*, *C.*, fragilis (Pers.) Fr., *B.*, *R.*, *A.*, *C.*, and var. fallax (Schaeff.) Massee, *B.*, emetica (Schaeff.) Fr., *B.*, *R.*, *S.*, *A.*, atropurpurea (Krombh.) Maire, *R.*, integra (Linn.) Bataille, *R.*, xerampelina (Schaeff.) Fr., *R.*, *A.*, *C.*, cutifracta Cooke, *R.*, puellaris Fr., *R.*, *A.*, nitida (Pers.) Fr., *R.*, vesca Fr., *R.*, ochracea (A. & S.) Fr., *A.*, mustelina Fr., *R.*, caerulea Cooke, *R.*, *A.*, *C.*, lutea (Huds.) Fr., *R.*, paludosa Britz., *R.*

Mycena elegans (Pers.) Fr., *A.*, atromarginata Fr., *B.*, *R.*, *A.*, rubromarginata Fr., *A.*, rosella Fr., *R.*, *A.*, *C.*, pura (Pers.) Fr., *B.*, *S.*, *R.*, *A.*, and var. carnea Rea, *R.*, Adonis (Bull.) Fr., *R.*, flavo-alba Fr., *S.*, *R.*, rugosa Fr., *B.*, *R.*, polygramma (Bull.) Fr., *R.*, alcalina Fr., *R.*, *A.*, ammoniaca Fr., *B.*, *S.*, *A.*, metata Fr., *R.*, amicta Fr., *A.*, debilis Fr., *A.*, vitilis Fr., *B.*, *S.*, haematopus (Pers.) Fr., *S.*, sanguinolenta (A. & S.) Fr., *S.*, *R.*, galopus (Pers.) Fr., var. nigra Fl. Dan., *R.*, epipterygia (Scop.) Fr., *R.*, *A.*, clavicularis Fr., *R.*, *A.*

Collybia crassifolia (Berk.) Bres., *R.*, *C.*, maculata (A. & S.) Fr., *A.*, distorta Fr., *R.*, butyracea (Bull.) Fr., *A.*, *R.*, cirrhata (Schum.) Fr., *R.*, *C.*, tuberosa (Bull.) Fr., *R.*, acervata Fr., *R.*, *A.*, atrata Fr., *R.*, *A.*

Marasmius oreades (Bolt.) Fr., *C.*, dryophilus (Bull.) Karst., *R.*, *A.*, *C.*, and var. aquosus (Bull.) Rea, *R.*, ramealis (Bull.) Fr., *S.*

Androsaceus androsaceus (Linn.) Pat., *R.*, insititius (Fr.) Rea, *C.*

Lactarius torminosus (Schaeff.) Fr., *B.*, *R.*, turpis (Weinm.) Fr., *S.*, aspideus Fr , *R.*, insulsus Fr., *R.*, blennius Fr., *R.*, uvidus Fr., *R.*, flexuosus Fr., *A.*, piperatus (Scop.) Fr., *B.*, vellereus Fr., *R.*, deliciosus (Linn.) Fr., *S.*, *R.*, *A.*, *C.*, sanguifluus (Paul.) Fr., *C.*, aurantiacus (Fl. Dan.) Fr., *R.*, theiogalus (Fr.) Plowr., *A.*, vietus Fr., *R.*, *C.*, rufus (Scop.) Fr., *R.*, *A.*, glyciosmus Fr., *R.*, mitissimus Fr., *C.*, subdulcis (Pers.) Fr., *B.*, *R.*

Hygrophorus cerasinus Berk., *R.*, agathosmus Fr., *A.*, pratensis (Pers.) Fr., *B.*, virgineus (Wulf.) Fr., *R.*, metapodius Fr., *R.*, ceraceus (Wulf.) Fr., *B.*, *S.*, *R.*, *A.*, coccineus (Schaeff.) Fr., *B.*, *S.*, *R.*, *A.*, miniatus Fr., *R.*, Reai Maire, *R.*, puniceus Fr., *R.*, conicus (Scop.) Fr., *B.*, *S.*, *R.*, chlorophanus Fr., *R.*, psittacinus (Schaeff.) Fr., *S.*, *A.*, nitratus (Pers.) Fr., *R.*, *A.*

Clitocybe clavipes (Pers.) Fr., *B.*, *S.*, *R.*, *A.*, aurantiaca (Wulf.) Studer, *S.*, *A.*, odora (Bull.) Fr., *R.*, rivulosa (Pers.) Fr., *R.*, decastes Fr., *R.*, infundibuliformis (Schaeff.) Fr., *R.*, flaccida (Sow.) Fr., *R.*, ditopus Fr., *R.*

Laccaria laccata (Scop.) B. & Br., *B.*, *S.*, *R.*, *A.*, and var. amethystina (Vaill.) B. & Br., *R.*

Omphalia hepatica (Batsch) Fr., *A.*, campanella (Batsch) Fr., *R.*, *A.*

Pleurotus acerosus Fr., *R.*, porrigens (Pers.) Fr., *R.*
Cantharellus cibarius Fr., *B.*, *S.*, *R.*, *A.*, umbonatus (Gmel.) Fr., *A.*, tubaeformis Fr., *R.*, lutescens (Pers.) Fr., *R.*
Craterellus crispus (Sow.) Fr., *R.*
Panus conchatus (Bull.) Fr., *R.*, torulosus (Pers.) Fr., *B.*
Pluteus cervinus (Schaeff.) Fr., *B.*, *S.*, eximius Saund. & Sm., *R.*
Entoloma prunuloides Fr., *R.*, jubatum Fr., *B.*, rhodopolium Fr., *R.*, sericeum (Bull.) Fr., *B.*, *R.*, nidorosum Fr., *R.*, speculum Fr., *B.*
Nolanea pascua (Pers.) Fr., *S.*, *A.*, proletaria Fr., *A.*, *C.*, cetrata (Fr.) Schroet., *R.*, *A.*, mammosa (Linn.) Fr., *S.*
Leptonia lampropus Fr., *B.*, *S.*, *R.*, euchroa (Pers.) Fr., *R.*, chalybaea (Pers.) Fr., *R.*, sericella (Fr.) Quél., *S.*, formosa Fr., *R.*
Clitopilus prunulus (Scop.) Fr., *B.*, *S.*, *R.*, *C.*
Paxillus involutus (Batsch) Fr., *S.*, *A.*, *C.*, atrotomentosus (Batsch) Fr., *S.*, *R.*, *A.*, panuoides Fr., *R.*, giganteus (Sow.) Fr., *R.*
Rozites caperatus (Pers.) Karst., *R.*
Pholiota flammans Fr., *R.*, *C.*, mutabilis (Schaeff.) Fr., *B.*, *R.*, marginata (Batsch) Fr., *S.*, *R.*
Bolbitius fragilis (Linn.) Fr., *A.*
Inocybe rimosa (Bull.) Fr., *B.*, tomentosa (Jungh.) Quél., *S.*, geophylla (Sow.) Fr., *R.*, hirsuta (Lasch) Fr., *R.*, fastigiata (Schaeff.) Fr., *R.*
Astrosporina asterospora (Quél.) Rea, *C.*, calospora (Quél.) Rea, *R.*
Hebeloma sinuosum Fr., *R.*, fastibile Fr., *C.*, glutinosum (Lindgr.) Fr., *R.*, testaceum (Batsch) Fr., *A.*, mesophaeum Fr., *B.*, crustuliniforme (Bull.) Fr., *R.*, and var. minus Cooke, *C.*
Naucoria cidaris Fr., *R.*, escharoides Fr., *S.*, *R.*
Galera tenera (Schaeff.) Fr., *S.*, hypnorum (Schrank) Fr., *B.*, *S.*, *R.*, *A.*
Tubaria pellucida (Bull.) Fr., *R.*, crobulus Fr., *R.*
Flammula gummosa (Lasch) Fr., *S.*, *A.*, sapinea Fr., *R.*, *A.*, *S.*, tricholoma (A. & S.) Fr., *R.*, ochrochlora Fr., *R.*, *A.*
Cortinarius (Phlegmacium) claricolor Fr., *R.*, crassus Fr., *C.*, varius (Schaeff.) Fr., *R.*, cyanopus (Secr.) Fr., *R.*, multiformis Fr., *R.*, glaucopus (Schaeff.) Fr., *R.*, caerulescens Fr., *R.*, purpurascens Fr., *R.*, turbinatus (Bull.) Fr., *R.*, porphyropus (A. & S.) Fr., *R.*, *A.*
(Myxacium) arvinaceus Fr., *R.*, *A.*, mucosus (Bull.) Fr., *R.*, *A.*, elatior Fr., *R.*, *A.*, *C.*, livido-ochraceus Berk., *R.*, delibutus Fr., *R.*, vibratilis Fr., *R.*, *A.*
(Inoloma) argentatus (Pers.) Fr., *R.*, violaceus (Linn.) Fr., *R.*, alboviolaceus (Pers.) Fr., *R.*, *A.*, traganus Fr., *A.*, callisteus Fr., *R.*, *A.*, pholideus Fr., *B.*, *R.*, *A.*, sublanatus (Sow.) Fr., *A.*
(Dermocybe) tabularis (Bull.) Fr., *R.*, caninus Fr., *B.*, anomalus Fr., *A.*, lepidopus Fr., *B.*, *R.*, myrtillinus Fr., *R.*, phoeniceus (Bull.) Maire, *R.*, *A.*, semisanguineus (Brig.) Maire, *R.*, *A.*, sanguineus (Wulf.) Fr., *R.*, cinnamoneus (Linn.) Fr., *R.*, *A.*, venetus Fr., *R.*
(Telamonia) laniger Fr., *R.*, torvus Fr., *B.*, armillatus Fr., *B.*, *R.*, *A.*, *C.*, hinnuleus (Sow.) Fr., *R.*, *A.*, gentilis Fr., *R.*, *A.*, helvelloides Fr., *R.*, bovinus Fr., *R.*, *A.*, brunneus (Pers.) Fr., *R.*, hemitrichus Fr., *S.*, *R.*, stemmatus Fr., *R.*, rigidus Fr., *R.*
(Hydrocybe) armeniacus (Schaeff.) Fr., *R.*, *C.*, dilutus (Pers.) Fr., *R.*, castaneus (Bull.) Fr., *R.*, *C.*, leucopus (Bull.) Fr., *A.*, obtusus Fr., *R.*
Psaliota augusta Fr., *R.*, arvensis (Schaeff.) Fr., *S.*, *A.*, sylvicola (Vitt.) Fr., *R.*, sylvatica (Schaeff.) Fr., *S.*, haemorrhoidaria Kalchbr., *R.*, *A.*, *C.*
Stropharia aeruginosa (Curt.) Fr., *R.*, squamosa (Pers.) Fr., *S.*, semiglobata (Batsch) Fr., *B.*, *S.*, *C.*, *psathyroides Lange, *Culloden Battlefield*, C.R. & J.R.
Anellaria separata (Linn.) Karst., *S.*, *R.*
Hypholoma capnoides Fr., *R.*, *A.*, fasciculare (Huds.) Fr., *B.*, *S.*, radicosum Lange, *R.*
Gomphidius roseus (Fr.) Quél., *R.*, *A.*, viscidus (Linn.) Fr., *A.*, and var. testaceus Fr., *S.*, *R.*, maculatus (Scop.) Fr., *A.*, gracilis B. & Br., *R.*, *A.*

* New to Britain.

Panaeolus sphinctrinus Fr., *A.*, *C.*, campanulatus (Linn.) Fr., *B.*, *S.*, *R.*
Psathyra fibrillosa (Pers.) Fr., *B.*, *R.*
Psilocybe semilanceata Fr., *B.*, *S.*, *R.*
Coprinus lagopus Fr., *A.*, micaceus (Bull.) Fr., *R.*, Hendersonii Berk., *R.*, plicatilis (Curt.) Fr., *B.*, *R.*
Boletus luteus (Linn.) Fr., *R.*, *A.*, elegans (Schum.) Fr., *S.*, *R.*, *A.*, *C.*, flavidus Fr., *R.*, *C.*, viscidus (Linn.) Fr., *R.*, badius Fr., *B.*, *S.*, *R.*, *A.*, bovinus (Linn.) Fr., *R.*, *A.*, piperatus (Bull.) Fr., *B.*, *R.*, variegatus Fr., *R.*, *A.*, chrysenteron (Bull.) Fr., *R.*, *A.*, subtomentosus (Linn.) Fr., *B.*, *S.*, *R.*, *A.*, *C.*, pruinatus Fr., *R.*, edulis (Bull.) Fr., *B.*, *S.*, *R.*, *A.*, pinicola (Vitt.) Rea, *R.*, *C.*, erythropus (Pers.) Quél., *R.*, duriusculus Schulz., *R.*, versipellis Fr., *R.*, scaber (Bull.) Fr., *S.*, *R.*, *C.*, and var. niveus Fr., *R.*
Polyporus perennis (Linn.) Fr., *R.*, *A.*, nummularius (Bull.) Quél., *R.*, varius Fr., *B.*, Schweinitzii Fr., *R.*, betulinus (Bull.) Fr., *R.*, *B.*, *A.*, amorphus Fr., *A.*, adustus (Willd.) Fr., *R.*, caesius (Schrad.) Fr., *R.*, tephroleucus Fr., *C.*
Sistotrema confluens (Pers.) Fr., *R.*, *A.*
Fomes fomentarius (Linn.) Fr., *B.*, and var. nigrescens Lloyd, *B.*, annosus Fr., *R.*, igniarius (Linn.) Fr., *Av.*
Polystictus hirsutus (Wulf.) Fr., *R.*, versicolor (Linn.) Fr., *B.*, *S.*, *R.*, abietinus (Dicks.) Fr., *R.*, *A.*, *C.*
Poria hymenocystis B. & Br., *R.*, medulla-panis (Pers.) Fr., *R.*
Lenzites saepiaria (Wulf.) Fr., *R.*
Trametes rubescens (A. & S.) Fr., *R.*
Daedalea quercina (Linn.) Fr., on a conifer, *R.*
Merulius tremellosus (Schrad.) Fr., *B.*, *R.*
Phlebia merismoides Fr., *A.*
Mucronella calva (A. & S.) Fr., *R.*
Hydnum repandum (Linn.) Fr., *B.*, *R.*, *A.*, *C.*, and var. rufescens (Pers.) Fr., *R.*, fragile Fr., *R.*, imbricatum (Linn.) Fr., *R.*, nigrum Fr., *R.*, graveolens (Delastr.) Fr., *R.*, melaleucum Fr., *R.*, cyathiforme (Schaeff.) Fr., *R.*, compactum (Pers.) Fr., *R.*, aurantiacum (A. & S.) Fr., *R.*, ferrugineum Fr., *R.*, scrobiculatum Fr., *R.*
Odontia bicolor (A. & S.) Bres., *R.*, farinacea (Pers.) Quél., *R.*, *C.*
Thelephora palmata (Scop.) Fr., *C.*, terrestris (Ehrh.) Fr., *R.*
Hypochnus umbrinus (Fr.) Quél., *R.*, puniceus (A. & S.) Sacc., *B.*, *R.*, zygodesmoides (Ell.) Burt, *C.*, fumosus Fr., *A.*, *C.*
Stereum spadiceum Fr., *B.*, *R.*, rugosum (Pers.) Fr., *B.*, *R.*, hirsutum (Willd.) Fr., *R.*, purpureum (Pers.) Fr., *S.*
Corticium microsporum (Karst.) Bourd. & Galz., *A.*, *C.*, flavescens (Bon.) Mass., *C.*, subcoronatum v. Hoehn. & Litsch., *C.*, praetermissum (Karst.) Bres., *C.*, inaequale (v. H. & L.) Sacc. & Trott., *C.*, albostramineum (Bres.) Wakef., *C.*, comedens (Nees) Fr., *Av.*
Peniophora candida Lyman (= P. Aegerita v. H. & L.), *R.*, glebulosa (Fr.) Bres., *R.*, *A.*, *C.*, accedens Bourd. & Galz., *R.*, pallidula Bres., *C.*, byssoidea (Pers.) v. H. & L., *A.*, sanguinea (Fr.) Bres., *A.*, laevigata (Fr.) Mass., *R.*
Solenia anomala (Pers.) Fr., *R.*
Clavaria abietina (Pers.) Fr., *R.*, stricta (Pers.) Fr., *C.*, vermicularis Fr., *B.*, *R.*, fumosa (Pers.) Fr., *R.*
Pistillaria puberula Berk., *R.*
Exobasidium Vaccinii (Fuck.) Wor., *B.*, *R.*, *A.*, *C.*
Tremella foliacea (Pers.) Fr., *R.*, *A.*, encephala (Willd.) Quél., *C.*
Exidia recisa (Ditm.) Fr., *B.*, *R.*
Heterochaetella crystallina Bourd., *R.*, *A.*
Dacryomyces deliquescens (Bull.) Duby, *S.*
Calocera viscosa (Pers.) Fr., *R.*, *A.*

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers., *R.*
Lycoperdon umbrinum Pers., *B.*, *A.*, perlatum Pers., *S.* *R.*, pyriforme (Schaeff.) Pers., *R.*
Bovista nigrescens Pers., *R.*, *A.*
Sphaerobolus stellatus (Tode) Pers., *R.*

UREDINEAE.

Uromyces Orobi (Pers.) Plowr., *R.*, *A.*, *Av.*, Alchemillae (Pers.) Lév., *R.*, Valerianae (Schum.) Fuck., *S.*, Acetosae Schroet., *R.*, *Av.*
Puccinia Violae (Schum.) DC., *B.*, *R.*, *A.*, *C.*, Malvacearum Mont., *R.*, punctata Link, *C.*, Cirsii Lasch, *R.*, Andersoni B. & Br., *R.*, Leontodontis Jacky, *C.*, expansa Link, *R.*, *C.*, annularis (Str.) Schlecht., *R.*, obscura Schroet., *B.*, *C.*, graminis Pers., on *Agropyrum repens*, *R.*, holcina Eriks., *Av.*, Lolii Niels., on oats, *R.*
Gymnosporangium Juniperi Link, *Av.*, *R.*, *S.*, *C.*, clavariaeforme (Jacq.) Reess, *S.*, Sabinae (Dicks.) Wint., *Av.*
Triphragmium Ulmariae (Schum.) Link, *R.*, *Av.*
Phragmidium Fragariae (DC.) Wint., *R.*, mucronatum (Pers.) Schlecht., *S.*, Rubi-Idaei (Pers.) Karst., *S.*, *R.*
Coleosporium Campanulae (Pers.) Lév., *C.*, Euphrasiae (Schum.) Wint., *R.*, *A.*, *Av.*, Melampyri (Rebent.) Karst., *C.*, Senecionis (Pers.) Fr., *R.*, *C.*, Tussilaginis (Pers.) Kleb., *C.*
Cronartium ribicola Dietr., *R.*
Pucciniastrum Vacciniorum (Link) Diet., *R.*, *A.*
Chrysomyxa Empetri (Pers.) Rostr., *A.*
Milesina Blechni Syd., *R.*, *A.*, Dieteliana (Syd.) Magn., *C.*
Melampsoridium betulinum (Pers.) Kleb., *B.*, *S.*, *R.*, *C.*

USTILAGINEAE.

Ustilago Avenae (Pers.) Jens., *R.*, nuda (Jens.) Rostr., *R.*, striaeformis (West.) v. Niessl, *C.*
Cintractia Caricis (Pers.) Magn., on *Carex panicea*, *R.*
Urocystis Anemones (Pers.) Wint., *R.*, *Av.*, Violae (Sow.) Fisch. v. Waldh., *R.*
Entyloma microsporum (Ung.) Schroet., *R.*

PYRENOMYCETES.

Sphaerotheca pannosa (Wallr.) Lév., *S.*, Humuli (DC.) Burr., on *Spiraea*, *R.*
Podosphaera Oxyacanthae (DC.) de Bary, on Cherry, *R.*
Uncinula Aceris (DC.) Sacc., *S.*, *R.*, *A.*
Nectria cinnabarina (Tode) Fr., *S.*, *Av.*
Hypocrea pulvinata Fuck., on *Polyporus betulinus*, *B.*
Cordyceps ophioglossoides (Ehrh.) Link, *A.*, capitata (Holmsk.) Link, *C.*
Claviceps purpurea (Fr.) Tul., on *Anthoxanthum*, *R.*, *C.*, on Barley, *R.*, on *Festuca*, *Av.*
Sordaria caudata (Curr.) Sacc., *R.*
Bertia moriformis (Tode) de Not., on Beech and *Acer*, *R.*
Melanomma pulvis-pyrius (Pers.) Fuck., on Birch, *B.*
Teichospora obducens (Fr.) Fuck., on Ash, *C.*
Gibbera Vaccinii (Sow.) Fr., *A.*
Cucurbitaria Laburni (Pers.) Ces. & de Not., *Av.*
Stigmatea Robertiani Fr., *R.*
Eutypa hydnoidea (Fr.) von Hoehn., *R.*, flavovirescens (Hoffm.) Sacc., on *Acer*, *R.*
Calospora platanoidis (Pers.) Niessl, on *Acer*, *R.*
Melanconis stilbostoma (Fr.) Tul., *R.*, *B.*, Alni Tul., *Av.*
Pseudovalsa lanciformis (Fr.) Ces. & de Not., on Birch, *B.*, *R.*
Diatrypella favacea (Fr.) Nits., on Birch, *B.*, verrucaeformis (Ehrh.) Nits., on Beech, *R.*
Diatrype Stigma (Hoffm.) de Not., on Birch, *R.*, *B.*, disciformis (Hoffm.) Fr. on Beech and *Acer*, *R.*
Calosphaeria pusilla (Wahl.) Karst., on Birch, *B.*
Hypoxylon multiforme Fr., on Birch and *Acer*, *B.*, *R.*
Daldinia vernicosa (Schw.) Ces. & de Not,, on burnt trunks of Birch, *C.*
Xylaria Hypoxylon (Linn.) Grev., *R.*
Dothidella ribesia (Pers.) Theiss. & Syd., *Av.*
Phyllachora Podagrariae (Roth) Karst., *C.*

HYSTERIALES.

Hysterographium Fraxini (Pers.) de Not., *C.*
Lophium mytilinum (Pers.) Fr., on coniferous wood, *R.*

DISCOMYCETES.

Helvella lacunosa Afz., *R.*
Macropodia macropus (Pers.) Fuck., *B.*
Rhizina inflata (Schaeff.) Karst., *R.*
Aleuria umbrina Boud., *S.*
Galactinia badia (Pers.) Boud., *R.*
Geopyxis carbonaria (A. & S.) Sacc., *R.*
Peziza aurantia Pers., *R.*, *A.*
Ciliaria scutellata (Linn.) Quél., *R.*
Humaria coccinea (Cr.) Quél., *R.*
Coprobia granulata (Bull.) Boud., *R.*
Taphrina aurea (Pers.) Fr., *R.*, Potentillae Farl., *R.*, *Av.*, Tosquinetii (West.) P. Magn., *S.*, *R.*, *A.*
Geoglossum ophioglossoides (Linn.) Sacc., *S.*, *R.*
Spathularia clavata (Schaeff.) Sacc., *R.*
Cudonia circinans (Pers.) Fr., *A.*
Coryne sarcoides (Jacq.) Tul., *B.*, *R.*
Sclerotinia Candolleana (Lév.) Fuck., *R.*
Stromatinia baccarum (Schroet.) Boud., *R.*
Chlorosplenium aeruginosum (Oeder) de Not., *B.*, *R.*
Ephelina Rhinanthi (Phill.) Sacc., sclerotium on *Rhinanthus*, *C.*
Mollisia cinerea (Batsch) Karst., *B.*
Scleroderris ribesia (Pers.) Karst., *Av.*
Trochila Buxi Capron, *Av.*
Pseudopeziza Trifolii (Biv.-Bern.) Fuck., *Av.*, Ranunculi (Wallr.) Fuck., *R.*, Ribis Kleb., *S.*
Rhytisma acerinum (Pers.) Fr., *S.*, *R.*, salicinum (Pers.) Fr., *A.*

PHYCOMYCETES.

Cystopus candidus (Pers.) de Bary, *Av.*
Peronospora Ficariae Tul., on *Ranunculus repens*, *Av.*, grisea de Bary, *R.*
Plasmopara nivea (Ung.) Schroet., on *Angelica sylvestris*, *Av.*
Synchytrium aureum Schroet., on *Cardamine*, *A.*, Succisae de Bary & Wor. on *Scabiosa succisa*, *A.*
Physoderma Menyanthis de Bary, *A.*

PROTOMYCETACEAE.

Protomyces macrosporus Unger, *C.*

DEUTEROMYCETES.

Rhizosphaera Kalkhoffii Bubák, *Av.*
Septoria Violae West., *S.*
Gloeosporium quercinum Westend., *R.*
Leptothyrium alneum (Lév.) Sacc., *Av.*
Ovularia obliqua (Cooke) Oud., *S.*, destructiva (Plowr. & Phill.) Mass., *B.*
Ramularia lactea (Desm.) Sacc., *R.*, Valerianae Speg., *Av.*, *S.*, Ulmariae Cooke, *Av.*, Primulae Thuem., *R.*
*Cercosporella Filicis-foeminae (Bres.) von Hoehn., *Av.*
Sepedonium chrysospermum (Bull.) Fr., *A.*
Bispora monilioides Corda, *A.*, *C.*
Cercospora Mercurialis Pass., *S.*, *R.*, Bloxami B. & Br., *R.*

* New to Britain.

MYCETOZOA FOUND DURING THE AVIEMORE FORAY.

September 12th to 17th, 1927.

By G. Lister, F.L.S.

Our hunting grounds around Aviemore consisted chiefly of native woods of Scots pine, with an undergrowth of heather, bilberry and cowberry, abounding in old stumps, and some open woods of birch; extensive sawdust heaps where pine timber had been cut up also gave good hunting. After a wet season and during a week of showery weather it was natural that the Mycetozoa should be abundant in the plasmodium stage, and that mature sporangia were often found in a weather-beaten condition. Forty species were obtained of which one, *Oligonema nitens*, appears to be a new record for Scotland.

The following is a list of the species recorded:

Ceratiomyxa fruticulosa (Muell.) Macbr. The plasmodium was found emerging from sawdust beds in the form of numerous low watery-white cushions, 5 to 20 mm. diam., and of a tenacious gelatinous consistency; specimens brought indoors developed typical branching sporophores next day.

Badhamia lilacina (Fries) Rost. A large growth of the lemon-yellow plasmodium, embedded in hyaline mucilage, was found on wet grass and heather near water; it developed indoors into clusters of pink-grey sporangia.

Physarum murinum Lister. Immature whitish sporangia scattered over pine needles and a gelatinous fungus, developed indoors into brownish white sporangia on very short yellowish stalks enclosing lime-granules: in the substance of the sporangium walls and also in the pale lime-knots discoid crystalline bodies often occur, a feature frequently met with in this species.

P. nutans Pers., abundant; var. *leucophaeum* also seen.

P. viride (Bull.) Pers. Two gatherings.

Fuligo septica (L.) Gmel. Very abundant on stumps and sawdust, also vars. *candida* R. E. Fries and *rufa* R. E. Fries. A bright yellow aethalium shading into red below was also obtained.

F. muscorum Alb. & Schw. The apricot-coloured plasmodium was frequently found forming gelatinous masses on heather and grass and matured into yellowish grey aethalia in a few days.

Craterium minutum (Leers) Fries. On dead leaves.

Leocarpus fragilis (Dicks.) Rost. On grass and rushes.

Didymium nigripes Fries. On dead leaves.

D. melanospermum (Pers.) Macbr. Formed clusters of more or less confluent sporangia on moss and pine needles.

Colloderma oculatum (Lippert) G. Lister. On decayed wood.

Stemonitis fusca Roth. Typical sporangia were found on dead wood. A small nearly sessile form matured from a white stage found on tufts of moss and heather; they are curved and stunted, but the columellae and capillitium are well developed and the spores are marked with a delicate and rather irregular warted reticulation. It appears to be the form described by Dr Jahn as characteristic of open moorland and named by him *Stemonitis trechispora* Torrend (Myxomycetenstudien, XI, in *Ber. Deutsch. bot. Gesellsch.* XLI, 394, 1924): the specimen he kindly sent me from moors near Berlin has stunted sporangia and ill-developed capillitium, but neither in this gathering nor in that from the Aviemore moorland are the

spores marked with the striking reticulation of continuous ridges characteristic of *S. fusca* var. *trechispora* Torrend; the stunted growth of the sporangia seems to be due to the exposed moorland habitat, and in the Aviemore specimen to injury by gathering.

S. hyperopta Meylan. On dead pine wood.

Comatricha nigra (Pers.) Rost. Frequent on sticks; a very minute form with a smooth surface net in the lower part of the capillitium was abundant on pine chips and barked branches.

C. elegans (Racib.) Lister. On pine wood.

Enerthenema papillatum (Pers.) Rost. On pine wood.

Lamproderma echinulatum Rost. A large growth of brilliant iridescent blue and green sporangia was found in a decayed pine stump; most sporangia are normal and have hyaline walls, and pale sparingly-branched capillitium. Some sporangia have curious bladder-like expanions near the tips of the capillitium, and others have half the sporangium-walls purple and rough on the outside with dark close-set spinules; the other half of the wall is pale purplish and smooth, or marked with small scattered clusters of spinules. This is a fresh instance of the variations that may appear in the sporangia of this difficult genus. In the light of the sessile varieties that have been found of *L. cribrarioides* R. E. Fries and in *L. atrosporum* Meylan, it seems probable that the single known specimen of *L. insessum* G. Lister is an irregular sessile form of *L. echinulatum*, with which it agrees in having very large prickly spores.

Cribraria rufa (Roth) Rost. Abundant on decayed pine wood.

C. vulgaris Schrad. Abundant and showing much variety in the size and shape of the nodes of the sporangial net.

C. piriformis Schrad. var. *notabilis* Rex. On sawdust, maturing from slate-grey plasmodium.

Dictydium cancellatum (Batsch) Macbr. Frequent; vars. *fuscum* Lister and *anomalum* Jahn were also found.

Lindbladia effusa (Ehrenb.) Rost. On sawdust.

Licea flexuosa Pers. Abundant on barked pine sticks and chips.

Tubifera ferruginosa Gmel. Very abundant in all stages on pine stumps.

Enteridium olivaceum (Schum.) Ehrenb. On birch wood.

Lycogala epidendrum (L.) Fries. Common.

Trichia persimilis Karsten. On decaying birch wood.

T. affinis de Bary. The single growth found has spores marked with a wide reticulation of very narrow bands. *T. decipiens* (Pers.) Macbr. and *T. Botrytis* Pers. were also found.

Oligonema nitens (Lib.) Rost. A group of eight minute sporangia was found on a pine stump.

Arcyria denudata (L.) Wettst., *A. incarnata* Pers., *A. cinerea* (Bull.) Pers. and *A. pomiformis* (Leers) Rost. were recorded.

Perichaena corticalis (Batsch) Rost. Abundant on birch bark.

Dianema corticatum Lister. Matured from rosy plasmodium found on an old fencing post.

This is a small list compared with the large one of eighty-one species obtained during the Forres foray of 1912; it includes five species not met with on that occasion, namely *Badhamia lilacina, Physarum murinum, Cribraria piriformis, Oligonema nitens* and *Arcyria pomiformis.*

LICHENS OF AVIEMORE DISTRICT.

By H. H. Knight, M.A.

Lichens are plentiful everywhere about Aviemore, but no species of the family Graphidaceae were seen. This perhaps is due to the cold climate for it is situated about 700 ft. above sea level. Another feature was the abundance of Gyrophorae found everywhere on boulders from the level of Aviemore up to the summits of the mountains. Other common lichens were *Evernia furfuracea* and three species of *Parmelia*, *P. pubescens*, *P. corniculata* and *P. exasperata*. *Ramalina fraxinea* was plentiful on trees on the road to Loch an Eilean, though not seen elsewhere. The apothecia of *Parmelia physodes* were common, and other lichens seen fertile were *Sphaerophorus globosus*, *Parmelia saxatilis* and *P. omphalodes* and *Gyrophora polyphylla*. The following rare lichens were found: *Parmelia multifida* and *Bilimbia rhexoblephara* on Craig Ellachie, the latter growing on *Gymnomitrium obtusum*, *Staurothele umbrina* and *Psorotichia furfurella* on a stone by Loch Vaa picked up by Miss Lorrain Smith, and *Lecidea antiloga* on palings at Boat of Garten. This last is one of Dr Stirton's species found by him at Aviemore.

A hurried visit was paid to Cairngorm, and here at an altitude of about 3000 ft. were seen *Cetraria nivalis*, *Alectoria nigricans* and *Cerania vermicularis*, and on a compact mass of Hepatics consisting mainly of *Gymnomitrium concinnatum*, *G. varians* and *Marsupella apiculata*, the two alpine lichens *Lecidea limosa* and *Biatorina contristans* were picked up. *Cetraria nivalis* was also brought back by Dr Darbishire from Geal-chàrn Beag.

The parasitic fungus *Ticothecium ventosicolum* was found growing on *Haematomma ventosum* on Craig Ellachie.

I am indebted to Mr Paulson for help in compiling this list, amounting to 160 species, varieties and forms.

Calicium hyperellum Ach.
C. curtum Turn. & Borr.
Sphaerophorus globosus Wain.
S. fragilis Ach.
Psorotichia furfurella Boist.
Pannaria pezizoides Leight.
Psoroma hypnorum S. F. Gray
Peltigera canina Willd.
P. rufescens Hoffm.
var. praetextata Nyl.
P. polydactyla Hoffm.
P. apthosa Willd.
Parmelia physodes Ach.
P. pubescens Wain.
P. corniculata A. L. Sm.
P. saxatilis Ach.
P. sulcata Tayl.
P. multifida A. L. Sm.
P. exasperata Carroll
P. omphalodes Ach.
P. fuliginosa Nyl.
and var. laetevirens Nyl.
Cetraria glauca Ach.
and var. tenuisecta A. L. Sm.
C. chlorophylla Wain.
C. nivalis Ach.
C. islandica Ach.
and f. platyna Fr.

C. aculeata Fr.
and f. hispida Cromb.
Evernia prunastri Ach.
E. furfuracea Mann.
Ramalina calicaris Fr.
R. fraxinea Ach.
R. farinacea Ach.
Usnea florida Web.
var. hirta Ach.
Alectoria nigricans Nyl.
A. jubata Ach.
A. chalybeiformis Th. Fr.
Cerania vermicularis S. F. Gray
Xanthoria parietina Th. Fr.
X. polycarpa Oliv.
X. lychnea Th. Fr.
Placodium dissidens Nyl.
P. murorum DC.
P. citrinum Hepp
P. cerinum Hepp
Physcia pulverulenta Nyl.
P. stellaris Nyl.
P. hispida Tuckerm.
Rinodina sophodes Th. Fr.
Lecanora subfusca Ach.
and var. pinastre Schaer.
L. rugosa Nyl.
L. atra Ach.
L. pallida Schaer.
L. carpinea Wain.
L. subcarnea Ach.
L. galactina Ach.
L. varia Ach.
L. symmicta Ach.
L. piniperda Koerb.
L. expallens Ach.
and var. lutescens Nyl.
L. sulphurea Ach.
L. polytropa Schaer.
L. badia Ach.
L. tartarea Ach.
and var. frigida Ach.
L. subtartarea Nyl.
L. parella Ach.
L. gibbosa Nyl.
L. caesiocinerea Nyl. f. obscurata Nyl.
L. lacustris Th. Fr.
Acarospora fuscata Th. Fr.
A. sinopica Koerb.
Lecania syringea Th. Fr.
Icmadophila ericetorum A. Zahlbr.
Haematomma ventosum Massal.
Pertusaria velata Nyl.
P. globulifera Nyl.
P. faginea Leight.
P. lactea Nyl.
P. pertusa Dal. Tor. & Sarnth.
P. dealbata Cromb.
P. leioplaca Schaer.
Gyrophora proboscidea Ach.
G. polyphylla Hook.
G. cylindrica Ach.
G. torrefacta Cromb.
G. polyrrhiza Koerb.
Baeomyces rufus DC.
B. roseus Pers.
Stereocaulon evolutum Graewe
S. paschale Fr.
S. denudatum Floerke
Cladonia rangiferina Web.
C. sylvatica Hoffm.
C. uncialis Web.
C. foliacea Willd.
C. pyxidata Hoffm.
C. lepidota Nyl. f. hypophylla Cromb.
C. cervicornis Schaer.
C. verticillata Floerke
C. gracilis Willd.
C. furcata Schrad.
C. squamosa Hoffm.
C. deformis Hoffm.
C. coccifera Willd.
C. flabelliformis Wain.
C. macilenta Hoffm.
Coenogonium ebeneum A. L. Sm.
Lecidea ostreata Schaer.
L. confertula Stirt.
L. lucida Ach.
L. granulosa Schaer.
L. uliginosa Ach.
L. fuliginea Ach.
L. turgidula Fée
L. sanguineoatra Ach.
L. fuscorubens Nyl.
L. antiloga Stirt.
L. parasema Ach.
L. limosa Ach.
L. lapicida Ach.
L. lithophila Ach.
L. Kochiana Hepp
L. griseoatra Schaer.
L. contigua Fr.
L. sorediza Nyl.
L. crustulata Koerb.
L. confluens Ach.
L. promiscens Nyl.
L. Dicksonii Ach.
L. lactea Floerke
L. fuscoatra Ach.
L. sanguinaria Ach.
Biatorina cyrtella Th. Fr.
B. premnea A. L. Sm.
B. contristans A. L. Sm.
Bilimbia melaena Arn.
B. rhexoblephara A. L. Sm.
Bacidia atrogrisea Arn.
B. umbrina Br. & Rostr.
Buellia myriocarpa Mudd
B. disciformis Mudd
B. atrata Mudd
B. badioatra Koerb.
B. Parmeliarum Oliv. on Parmelia exasperata.
Rhizocarpon Oederi Koerb.

R. geographicum DC.
R. petraeum Massal.
R. confervoides DC.
R. obscuratum Massal.
Arthonia radiata Ach.
and var. Swartziana Sydow
Verrucaria margacea Wahlenb.
Staurothele umbrina A. L. Sm.
Arthopyrenia epidermidis Mudd
A. punctiformis Arn.
A. fallax Arn.

REVIEWS.

La spore des champignons supérieurs. By E. J. GILBERT. Paris: Le François. 1927. 221 pp., 1 text-fig., 1 pl. 20 frs.

The full title of this booklet, which proceeds "couleur, forme, ornementation, terminologie, valeur taxonomique," explains the main contents. M. Gilbert is however one of the younger school of French mycologists, and each generation seems to produce a number of investigators who endeavour to press the classification of the Basidiomycetes on to a more solid basis. There appears to be such a movement at present and the work under review contains many hints of this. A plea is made for precision particularly in the description of spores—shape, ornamentation and colour being regarded as of more importance than size. Points of technique are elaborated which will be of use to amateurs, but there is incidental mention of many facts which will make the work interesting even to those who need no conversion to the main thesis. Gilbert's attitude may best be expressed in his own words "Les mycologues, confinés dans une antique routine, sont les premières victimes de leurs déplorables méthodes de travail." It is to be hoped that those who intend to quote this or similar sentences will first take the trouble to study the book. J. R.

Clef dichotomique pour la détermination des levures. By A. GUILLIERMOND. Paris: Le François. 1928. 124 pp., text-figs. 14 frs.

Professor Guilliermond is probably the student of yeasts best known to general botanists. He has produced a booklet which will be useful to those who do not desire to take their diagnoses further than the genus. The first fifty pages deal with general matters—general characteristics, methods of culture and observation, isolation, methods of diagnosis; this makes a useful introduction to the study of yeasts. In the dichotomous key many species of interest are mentioned with the reference to their description; here also there are odd notes on nomenclature, and a criticism of Zendner's classification of the Endomycetaceae. *Sporobolomyces* is included among the yeasts, cytological investigation by the author having shown that its proper position is there and not amongst the Basidiomycetes. It may be

mentioned that *Medusomyces* referred to in a footnote has been shown by Lindner and others to be a compound "organism" owing its gelatinous consistency to *Bacterium xylinum*. A summary of the key is given in the last six pages. There are numerous text-figures which, though rough, serve their purpose.

J. R.

Die Pilze Mitteleuropas. Bd. 1. Die Rohrlinge (Boletaceae). By F. KALLENBACH. Lief. 6 and 7, pls. 15, 16, 17, 18 and 23, pp. 29–44.

The plates in these further instalments of the Boletaceae deal respectively with *Boletus luridus* (15 and 16), *B. elegans-flavus* (17), *B. viscidus* (18), dissections of these species, and habitat photographs of *B. luridus* and *B. luteus* (23). The text of eight pages does not quite complete the account of the first three species. The great variability of *B. luridus* is well depicted but the form with the olivaceous umber pileus which is regarded as typical in this country is unaccountably absent, though the very rare form with sulphur-yellow pores is figured.

Boletus flavus (With. 1796) Fr. 1835 is regarded as synonymous with *Boletus elegans* Fr. (non Schum.) Fr. 1836–38 and the var. *pulchella* dropped. It appears from the order of the names on the plates and from an occasional slip in writing *elegans* that the author would have preferred to use this name.

The figures well represent the range of the species as seen with us. Great insistence is put upon its occurrence under larch. Fries in 1874 says "semper sub Larice," but it is certain that in this country though almost always under larch it is not invariably so, though how one is to provide Melin with the "kritische Nachprüfung" he demands is difficult to see.

The plate of *Boletus viscidus* shows the fungus in the forms well known to British mycologists. It is said to occur under larch but less frequently than *B. flavus*. One's impression is that there is little to choose between the two in that respect here. A point of interest to those studying mycorrhiza is that *B. viscidus* sometimes forms a ring round the bole of the larch. I have known one in Surrey for several years, the fruit-bodies appearing in wet summers in July.

The publication maintains its high standard of production.

J. R.

Mycorrhiza. An account of non-pathogenic infection by fungi in vascular plants and Bryophyta. By M. C. RAYNER. *New Phytologist*, Reprint No. 15. Wheldon and Wesley, Ltd. 1927. 246 pp., 7 pls., 64 text-figs.

Botanists in general will welcome this summary of our knowledge of mycorrhiza, that strange association of fungus and

green plant so common under natural conditions. There have been several previous connected accounts but so much has been accomplished during the last few years that it is convenient to have these investigations strung together. Dr Rayner has however not restricted herself to the more modern work but has included the earliest observations. Perhaps this is not undesirable as no complete account has appeared previously in English; no references additional to those already well known appear to have been unearthed.

It is when we reach Bernard's work on orchid mycorrhiza that the account begins to be of general interest, for when properly understood this is full of suggestions on plant life in general. The author deals with it in some detail but curiously enough treats Burgeff very curtly—though she has made some slight amends by reviving him from the early death conferred upon him in the original articles. Most mycologists are conversant with the general results of these two workers. Much remains to be done along the trail blazed by Bernard, but there are few suggestions about the lines that would probably prove the most profitable: it cannot be held that the possibility of nitrogen fixation is the main problem to be solved.

The work on Ericaceae, in which the author has played a leading part, is treated in some detail. Her further work on this group will be awaited with interest, for there are several points about *Calluna* which still require either confirmation or amplification.

Melin's investigations on the mycorrhiza of forest trees is detailed to a degree which appears unnecessary in view of the fact that the account is uncritical. The evidence for an obligate relation between tree and Basidiomycete is not so strong as Melin holds. Even so strong an association as that between *Boletus elegans* and Larch is not invariable. I have sometimes seen this fungus away from the larch—twice last year, once near Leith Hill, Surrey, and at Inverness (in company with Mr Rea) with no larch in sight. Incidentally it might have been useful to non-mycologists to have given the synonyms used in this country for species such as *Amanita rubens* and *A. citrina*.

The eleven chapters of the book end with one on tuberisation and one on physiology and nutrition. The impression which will probably be left in some minds is one of confusion, but that is probably unavoidable when the whole of the information on mycorrhiza is reviewed. The author shows clearly where her sympathies lie when dealing with the part of the subject which she has especially studied but fails to give a clear lead with the common "Phycomycete" type and tree mycorrhiza. It cannot be said at present that Peyronel's idea of a double infection of

"Phycomycete" and *Rhizoctonia* has been proved. Much careful work has been done by investigators who would not have missed the typical *Rhizoctonia* pelotons if they had been present, and this should have been stressed.

Enough has been said to show that the book is one that should be in the possession of everyone wishing for an up-to-date account of mycorrhiza. The subject is many-sided and full of complexities. It is not possible at present to see what is the meaning of many facts—or even to judge of the truth of many records of observation.

The book is well printed, is well illustrated and has a very full list of references. J. R.

PROCEEDINGS, 1927–28.

AUTUMN FORAY AND ANNUAL MEETING, AVIEMORE.

12th–17th September, 1927.

MEETING. UNIVERSITY COLLEGE, LONDON. *19th November*, 1927.

S. F. Ashby. The oospores of *Phytophthora Nicotianae*, with notes on the taxonomy of *P. parasitica*.
B. F. Barnes. On the production of variations in *Eurotium*.
S. Garside. Method of reproduction in *Siphula tabularis*.
R. M. Nattrass. The *Physalospora* disease of Basket Willow.

MEETING. UNIVERSITY COLLEGE, LONDON. *21st January*, 1928.

E. J. Butler. Morphology of *Catenaria* in the Eggs of the Liver Fluke.
M. M. Duke. The genera *Vermicularia* and *Colletotrichum*.
N. C. Preston. A *Cercospora* leaf-spot of Turnip.
J. Ramsbottom. Mycological Nomenclature.

MEETING. UNIVERSITY COLLEGE, LONDON. *24th March*, 1928.

E. S. Salmon and W. M. Ware. Two downy Mildews of the Nettle.
E. J. Schwartz and W. R. Ivimey Cook. Life History of a new species of *Olpidium*.
W. B. Brierley, W. Brown, G. G. Hahn, and H. Wormald. Symposium on the Nomenclature of Strains.

SPRING FORAY FOR LONDON STUDENTS, EFFINGHAM.

12th May, 1928.

SPRING FORAY, OXFORD. *18th–22nd May*, 1928.

ERRATUM

p. 80, lines 4 and 5 from bottom of page.

Pseudopycnis Malorum Potebnia should read *Phacidiopycnis Malorum* Potebnia.

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195. Lowndes, Mr A. G., M.A., Marlborough College, Marlborough, Wilts. (1922.)
196. MacCallum, Mrs B. D., M.A., D.Sc., F.L.S., c/o Professor MacCallum, Department of Pathology, University of Melbourne, Australia. (1921.)
197. Mackenzie, Miss A. D., Research Station, East Malling, Kent. (1921.)
198. Mackenzie, Mr D., . (1900.)
199. Madras University Library, Madras, South India. (1925.)
200. Maire, M. René, D.Sc., Professeur à la Faculté des Sciences de l'Université, Algiers, Algeria, N. Africa. (1907.)
201. Maltby, Mr G. C., 14, Northwick Road, Evesham. (1923.)
202. Marsh, Mr R. W., M.A., Research Station, Long Ashton, Bristol. (1923.)
203. Martyn, Mr E. B., B.A., 27, Belgrave Road, London, S.W. 1. (1927.)
204. Mason, Mr E. W., M.A., M.Sc., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1921.)
205. Mason, Mrs E. W., Suffield House, Paradise Road, Richmond, Surrey. (1922.)

206. Mason, Mr F. A., F.R.M.S., M.S.P.A., 29, Frankland Terrace, Leeds. (1912.)
207. Matthews, Mr J. R., M.A., F.I.S., Royal Botanic Gardens, Edinburgh. (1921.)
208. McDonald, Mr J., B.Sc., Mycologist, Department of Agriculture, Box 323, Nairobi, Kenya Colony, East Africa. (1923.)
209. McFarland, Dr Frank T., Department of Botany, University of Kentucky, Lexington, Ky., U.S.A. (1924.)
210. McLean, Professor R. C., M.A., D.Sc., F.L.S., Botany School, University College, Cardiff. (1922.)
211. McLennan, Dr Ethel I., Botanical Department, Melbourne University, Carlton, Victoria, Australia. (1926.)
212. Mehta, Professor K. C., Ph.D., Department of Biology, Agra College, Agra, U.P., India. (1921.)
213. Metcalfe, Mr C. R., B.A., Westport, Wareham, Dorset. (1926.)
214. Meulenhoff, Dr J. S., President, Dutch Mycological Society, Diezerstraat, Zwolle, Holland. (1921.)
215. Michigan Agricultural College Library, East Lansing, Michigan, U.S.A. (1924.)
216. Millard, Mr W. A., B.Sc., The Agriculture Department, The University, Leeds. (1924.)
217. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902.)
218. Mitra, Mr M., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1928.)
219. Miyabe, Dr Kingo, Professor of Botany, Hokkaido Imperial University, Sapporo, Japan. (1919.)
220. Mohendra, Mr K. R., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1927.)
221. Montague, Mrs A., Penton, Crediton, N. Devon. (1898.)
222. Moore, Miss E. S., Ph.D., c/o the Secretary, Department of Agriculture, P.O. Box 994, Pretoria, South Africa. (1923.)
223. Moore, Mr W. C., M.A., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1922.)
224. Morgan, Dr G., Ashley-Hatton, Dyke Road Avenue, Brighton. (1928.)
225. Morris, Mr L. E., Rubber Research Institute, Kuala Lumpur, Federated Malay States. (1924.)
226. Moss, Professor C. E., The University, P.O. Box 1176, Johannesburg, South Africa. (1923.)
227. Murphy, Professor P. A., Sc.D., A.R.C.Sc.I., M.R.I.A., Department of Plant Pathology, Albert Agricultural College, Glasnevin, Dublin, N.W. 3. (1924.)
228. Murray, Mr G. H., F.E.S., Papuan Government Service, Port Moresby, Papua, British New Guinea. (1921.)
229. Murrell, Major Percy J., O.B.E., F.R.M.S., "Littlecroft," Orpington, Kent. (1923.)

230. Muskett, Mr A. E., B.Sc., A.R.C.S., Queen's University, Belfast, North Ireland. (1923.)
231. National Collection of Type Cultures, Curator, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
232. Nattrass, Mr R. M., B.Sc. (Agric.), Ph.D., Plant Protection Section, Ministry of Agriculture, Cairo, Egypt. (1925.)
233. Nebraska, The Library, University of, Lincoln, Nebr., U.S.A. (1924.)
234. Nederlandsche Mycologische Vereeniging, c/o H. A. A. van der Lek, Zoomweg 10, Wageningen, Holland. (1920.)
235. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904.)
236. Nicholson, Mr W. E., F.L.S., 50, St Anne's Crescent, Lewes. (1913.)
237. Nirula, Mr Ram Lal, Ph.D. (Lond.), D.I.C., Ghangwal, Jhawrian, Sargodha, Punjab, India. (1927.)
238. Noel, Miss E. F., F.L.S., 37, Moscow Court, Queen's Road, London, W. 2. (1913.)
239. Norman, Mr L. Stafford, Konjeni Estate, Luchenza P.O., Nyasaland. (1927.)
240. North Carolina, Library, University of, Chapel Hill, North Carolina, U.S.A. (1920.)
241. Nursery and Market Garden Industries' Development Society, Ltd., Experimental and Research Station, Cheshunt, Herts. (1922.)
242. Nutman, Mr F. J., B.Sc., A.R.C.S., East African Agricultural Research Institute, Amani, Tanganyika Territory, East Africa. (1926.)
243. O'Connor, Mr P., B.Sc., A.R.C.Sc.I., College of Science, Upper Merrion Street, Dublin. (1925.)
244. Ogilvie, Mr L., M.A., M.Sc., Research Station, Long Ashton, Nr Bristol. (1922.)
245. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove, Sussex. (1908.)
246. Ontario Agricultural College, Library, Guelph, Ontario, Canada. (1920.)
247. Osborn, Professor T. G. B., M.Sc., Botanical Department, The University, Sydney, N.S.W., Australia. (1910.)
248. Ottawa, Ontario, Canada, The Library, Geological Survey. (1926.)
249. Page, Miss W. M., B.Sc., 19, Ledam Buildings, Bourne Estate, Holborn, London, E.C. 1. (1921.)
250. Parke Davis & Co., Librarian, Research Department, Detroit, Michigan, U.S.A. (1920.)
251. Paul, The Very Rev. David, D.D., LL.D., F.L.S., 53, Fountainhall Road, Edinburgh. (1899.)

252. Paul, Mr W. R. C., M.Sc., D.I.C., F.L.S., Department of Agriculture, Peradeniya, Ceylon. (1928.)
253. Paulson, Mr Robert, F.L.S., F.R.M.S., Glenroy, Cecil Park, Pinner, Middlesex. (1918.)
254. Peacock, Dr H. G., The Lawn, Torquay. (1896.)
255. Pearson, Mr Arthur A., F.L.S., 59, Southwark Street, London, S.E. 1. (1911.)
256. Peklo, Dr Jaroslav, Professor of Applied Botany, Bohemian Technical University, Charles Square, Prague II, Czechoslovakia. (1924.)
257. Perthshire Society of Natural Science, c/o Mr James Winter (Hon. Treasurer), 35, George Street, Perth. (1919.)
258. Petch, Mr T., B.A., B.Sc., Tea Research Institute, Nuwara Eliya, Ceylon. (1911.)
259. Pethybridge, Mr G. H., Ph.D., B.Sc., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919.)
260. Philadelphia, The Academy of Natural Sciences of Philadelphia, Logan Square, Phila., U.S.A. (1925.)
261. Phillips, Dr H. H., 6, St John's Road, Penge, London, S.E. 10. (1923.)
262. Phillips, Mr J. F. V., B.Sc. (For.), D.Sc. (Edin.), Botanist (Tsetse Research), Game Preservation Department, Kondoa-Irangi, Tanganyika Territory, East Africa. (1921.)
263. Ping, Mr A. Wentworth, M.A., "St Olave's," Clifton, York. (1926.)
264. Plowright, Mr C. T. M., B.A., M.B., King Street, King's Lynn. (1901.)
265. Potter, Rev. M. C., Sc.D., M.A., F.L.S., Corley Croft, New Milton, Hants. (1896.)
266. Povah, Professor A. H., 9, Fisk Hall, Northwestern University, Evanston, Ill., U.S.A. (1924.)
267. Preston, Mr N. C., B.Sc., Harper Adams Agricultural College, Newport, Salop. (1920.)
268. Pretoria, South Africa, The Chief, Division of Botany (91403), Department of Agriculture. (1922.)
269. Priestley, Professor J. H., D.S.O., B.Sc., F.L.S., Botanical Department, The University, Leeds. (1912.)
270. Proefstation voor Thee, Department van Landbouw, Buitenzorg, Java. (1926.)
271. Pusa, Imperial Mycologist, Imperial Agricultural Research Institute, Pusa, Bihar, India. (1921.)
272. Ramsbottom, Mr J., O.B.E., M.A., F.L.S., British Museum, Cromwell Road, South Kensington, London, S.W. 7. (1910.)
273. Rayner, Mr J. F., Swaythling, Southampton. (1902.)

274. Rayner, Dr M. Cheveley (Mrs Neilson Jones), Bedford College for Women, Regent's Park, London, N.W. 1. (1921.)
275. Rea, Miss M. W., M.Sc., Salem House, Sydenham, Belfast, Ireland. (1920.)
276. Rea, Miss Violet, 6, Barbourne Terrace, Worcester. (1921.)
277. Reichert, Dr Israel, Plant Pathologist, Palestine Zionist Executive Agricultural Experiment Station, Tel-Aviv, Palestine. (1924.)
278. Rhind, Mr Donald, B.Sc., Economic Botanist, Department of Agriculture, Agricultural College, Mandalay, Burma. (1922.)
279. Rhodes, Miss Mabel, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
280. Richards, Mr R. M., M.B.E., A.R.C.S., F.L.S., The Laboratory, Caledonia Estate, Province Wellesley, Straits Settlements. (1915.)
281. Roberts, Mrs A. W. Rymer, The End House, Fulbrook Road, Cambridge. (1920.)
282. Robinson, Professor Wilfred, Stoneleigh, Caradog Road, Aberystwyth, N. Wales. (1923.)
283. Robson, Mr R., M.Sc., F.Z.S., East Hammingfield, Chelmsford, Essex. (1914.)
284. Rolfe, Mr T. R., F.I.C., 76, Spenser Road, Bedford. (1924.)
285. Roper, Miss Ida M., F.L.S., 4, Woodfield Road, Redland, Bristol. (1921.)
286. Rothamsted Experimental Station, Department of Mycology, Harpenden, Herts. (1923.)
287. Rutgers College and State University of New Jersey, Library, New Brunswick, New Jersey, U.S.A. (1922.)
288. Ryan, Mr G. M., F.L.S., 35, Ladbroke Gardens, London, W. 11. (1923.)
289. St Paul, Minnesota, U.S.A., The Library, Department of Agriculture, University Farm. (1920.)
290. Salisbury, Mr E. J., D.Sc., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1921.)
291. Salmon, Professor E. S., F.L.S., South-Eastern Agricultural College, Wye, Kent. (1922.)
292. Sampson, Miss K., B.Sc., University College, Aberystwyth, North Wales. (1920.)
293. Samuel, Mr Geoffrey, The University of Adelaide, South Australia. (1923.)
294. Sanderson, Mr A. R., F.L.S., 163, Ampang Road, Kuala Lumpur, Federated Malay States. (1921.)
295. Sawhney, Mr A., M.Sc., Panjab University, Lahore, India. (1927.)
296. Schinz, Professor Dr Hans, Botanical Garden and Museum, Zurich, Switzerland. (1921.)

297. Science Library, South Kensington, London, S.W. 7. (1924.)
298. Scott, Mr W. W., 23, Wood Lane, Highgate, London, N. 6. (1922.)
299. Searle, Mr G. Odell, B.Sc. (Agric.), Research Botanist, Linen Industry Research Association, Glenmore House, Lambeg, Lisburn, Ireland. (1920.)
300. Sharpe, Mr C. J., Brambleside, Manor Road, Sidcup. (1905.)
301. Sharples, Mr A., A.R.C.S., D.I.C., Mycologist, Department of Agriculture, Kuala Lumpur, Federated Malay States. (1924.)
302. Shaw, Mr F. J. F., D.Sc., A.R.C.S., F.L.S., Imperial Agricultural Research Institute, Pusa, Bihar, India. (1920.)
303. Small, Mr W., M.B.E., M.A., Ph.D., B.Sc., Mycologist, Royal Botanic Gardens, Peradeniya, Ceylon. (1915.)
304. Smith, Mr Alexander, M.A., Ph.D. Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1924.)
305. Smith, Mr F. E. V., B.Sc., Microbiologist, Department of Agriculture, Jamaica, B.W.I. (1922.)
306. Smith, Miss K. E., 64, Coton Road, Nuneaton. (1913.)
307. Smith, Professor Noel J. G., Ph.D., B.Sc., Botany Department, Rhodes University College, Grahamstown, S. Africa. (1924.)
308. Smith, Mr Rupert, 38, Greenhill Gardens, Edinburgh. (1927.)
309. Smith, Miss S. Somerford, 6, Barbourne Terrace, Worcester. (1923.)
310. Solberg, Miss Louise, Universitetets Botaniska Laboratorium, Kristian IV's gate 1, Oslo, Norway. (1923.)
311. South London Botanical Institute, 323, Norwood Road, Tulse Hill, London, S.E. 24. (1921.)
312. Southwell, Mr Herbert, A.R.C.S., 158, Lincoln Road, Peterborough. (1923.)
313. Stakman, Professor E. C., University of Minnesota, Minneapolis, Minn., U.S.A. (1922.)
314. Stansfield, Miss O. P., M.Sc., 70, Northcourt Avenue, Reading. (1922.)
315. Statham, Miss E. M., 262, Burrage Road, Woolwich, London, S.E. 18. (1926.)
316. Station de Pathologie Végétale, Étoile de Choisy, Route de St Cyr, à Versailles (Seine et Oise), France. (1928.)
317. Stationery Office, H.M., Superintendent of Publications, Book Dept., Westminster, S.W. 1. (2 subscriptions.) (1920.)
318. Stelfox, Mrs, "Mayfield," Clareville Road, Rathgar, Dublin. (1925.)
319. Stirrup, Mr H. H., M.Sc., Midland Agricultural College, Sutton Bonington, Loughborough. (1922.)

320. Storey, Mr H. H., B.A., East African Agricultural Research Institute, Amani, Tanganyika Territory, East Africa. (1922.)
321. Sutherland, Mr G. K., M.A., D.Sc., F.L.S., 110, Brackenbury Road, Moor Park, Preston. (1914.)
322. Swansea Field Naturalists' Society, c/o Mr Alan Stuart, M.Sc., University College, Singleton, Swansea, South Wales. (1924.)
323. Swanton, Mr E. W., A.L.S., Educational Museum, Haslemere, Surrey. (1899.)
324. Swedish Academy of Sciences, Royal, Stockholm, Sweden. (1919.)
325. Sydney, Australia, The Librarian, University of. (1922.)
326. Tabor, Mr R. J., B.Sc., F.L.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1914.)
327. Tagg, Mr H. F., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
328. Tandy, Mr Geoffrey, B.A., F.L.S., Department of Botany, British Museum, Cromwell Road, South Kensington, London, S.W. 7. (1925.)
329. Taylor, Miss B. K., 98, Cheyne Walk, Chelsea, London, S.W. 3. (1910.)
330. Tennessee, University of, Agricultural Experiment Station, Library, Knoxville, Tennessee, U.S.A. (1926.)
331. Thompson, Miss N. L., B.Sc., 4, Burton Court, London, S.W. 3. (1926.)
332. Tomkins, Mr R. G., B.A., Trinity College, Cambridge. (1925.)
333. United States Department of Agriculture, c/o Wheldon and Wesley, 2–4 Arthur Street, New Oxford Street, London, W.C. 2. (1907.)
334. Vines, Professor S. H., M.A., D.Sc., F.R.S., F.L.S., Langstone, Exmouth, Devon. (1915.)
335. Wadham, Professor S. M., M.A., Department of Agriculture, The University, Melbourne, Victoria, Australia. (1922.)
336. Wager, Mr H., D.Sc., F.R.S., F.L.S., 4, Bank View, Chapel Allerton, Leeds. (1896.)
337. Wakefield, Miss E. M., M.A., F.L.S., Herbarium, Royal Botanic Gardens, Kew. (1911.)
338. Waldie, Mr J. S. L., B.Sc., C.D.A., Department of Agricultural Botany, The University, Reading. (1925.)
339. Wales, University College of, Librarian, Botanical Department, Aberystwyth, North Wales. (1927.)
340. Wallace, Mr G. B., B.Sc. (Agric.), Ph.D., Department of Agriculture, Morogoro, Tanganyika Territory, East Africa. (1928.)

341. Wallace, Mrs G. B., B.Sc., Morogoro, Tanganyika Territory, East Africa. (1924.)
342. Wallis, Mr A., Westacre, Station Road, Kettering. (1921.)
343. Ward, Mr F. S., Department of Agriculture, Kuala Lumpur, Federated Malay States. (1925.)
344. Ware, Mr W. M., M.Sc., South-Eastern Agricultural College, Wye, Kent. (1924.)
345. Washington, Library, State College of Washington, Pullman, Wash., U.S.A. (1924.)
346. Waterhouse, Miss G. M., B.Sc., 35, Southdean Gardens, London, S.W. 19. (1927.)
347. Watson, Mr W., D.Sc., A.L.S., Taunton School, Taunton. (1923.)
348. Welsford, Miss E. J., The Dell Gardens, Englefield Green, Surrey. (1924.)
349. Westerdijk, Professor Johanna, Javalaan 4, Baarn, Holland. (1923.)
350. Weston, Mr W. A. R. Dillon, M.A., School of Agriculture, Cambridge. (1923.)
351. Whetzel, Professor H. H., M.A., New York State College of Agriculture, Cornell University, Ithaca, N.Y., U.S.A. (1914.)
352. Whitaker, Mr F. Owen, 45, Elmdene Road, Plumstead, London, S.E. 18. (1921.)
353. Whitehead, Mr T., Ph.D., A.R.C.S., University College of North Wales, Bangor. (1920.)
354. Wilkins, Mr W. H., M.A., Department of Botany, The University, Oxford. (1928.)
355. Williamson, Mrs H. S., B.Sc., 3, Verulam Buildings, Gray's Inn, London, W.C. 1. (1921.)
356. Wilson, Mr Malcolm, D.Sc., A.R.C.S., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
357. Wilson, Miss M. J., B.Sc., 23, Hoseside Road, Wallasey, Cheshire. (1927.)
358. Wiltshire, Mr S. P., M.A., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1920.)
359. Wiltshire, Mrs S. P., 24, Lawn Crescent, Kew Gardens, Surrey. (1925.)
360. Winsor, Mr A. P., A.R.C.Sc.I., Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W. 1. (1923.)
361. Wisconsin, The Library, University of, Madison, Wis., U.S.A. (1923.)
362. Wolf, Mr B. L., N.D.A., Cornwall Buildings, 45, Newhall Street, Birmingham. (1923.)
363. Woodcock, Mr A. J. A., M.Sc., F.E.S., Clifton Manor, York. (1926.)

364. Woodward, Mr R. C., Ph.D., School of Rural Economy, Oxford. (1924.)
365. Woolhope, The Naturalists' Field Club, Hereford, c/o Col. M. J. G. Scobie, 2, Offa Street, Hereford. (1896.)
366. Worcestershire Naturalists' Field Club, c/o Mr W. J. Else, Victoria Institute, Worcester. (1921.)
367. Wormald, Mr H., D.Sc., A.R.C.S., Research Station, East Malling, Kent. (1921.)
368. Wright, Mr E. Barton, B.Sc., Botanical Department, King's College, Strand, London, W.C. 2. (1926.)
369. Young, Miss Elaine M., University of the Witwatersrand, Johannesburg, South Africa. (1927.)

RULES.

Society's name and objects.

1. The Society shall be called "The British Mycological Society," and its objects shall be the study of Mycology in all its branches.

Members of Society.

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100*, but the number of Ordinary Members shall be unlimited.

Honorary Members.

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members.

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

Officers.

5. The Officers of the society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually at the Annual General Meeting of the Society.

Government of Society.

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct. 1903.

Period of Office.

7. The Officers and Council shall hold office as from the 1st of January following their election.

Election of Members.

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription.

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

Meetings.

10. The Society shall hold one or more Meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting for the election of Officers and the transaction of other business shall coincide with the Autumn Foray.

Accounts.

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules.

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alteration to all Members.

APPENDIX.

Form of proposal for Ordinary Membership of the British Mycological Society.

.....

of .....

.....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

.....(From personal knowledge).

Certificate to be signed by the Candidate.

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

.....

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